PETROLEUM REFINER

SPECIALIZED FOR THE OIL REFINING INDUSTRY, INCLUDING PETRO-CHEMICAL ENGINEERING, PETROLEUM SYNTHETICS AND NATURAL GASOLINE

May, 1945
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GRADY TRIPLETT
Editor

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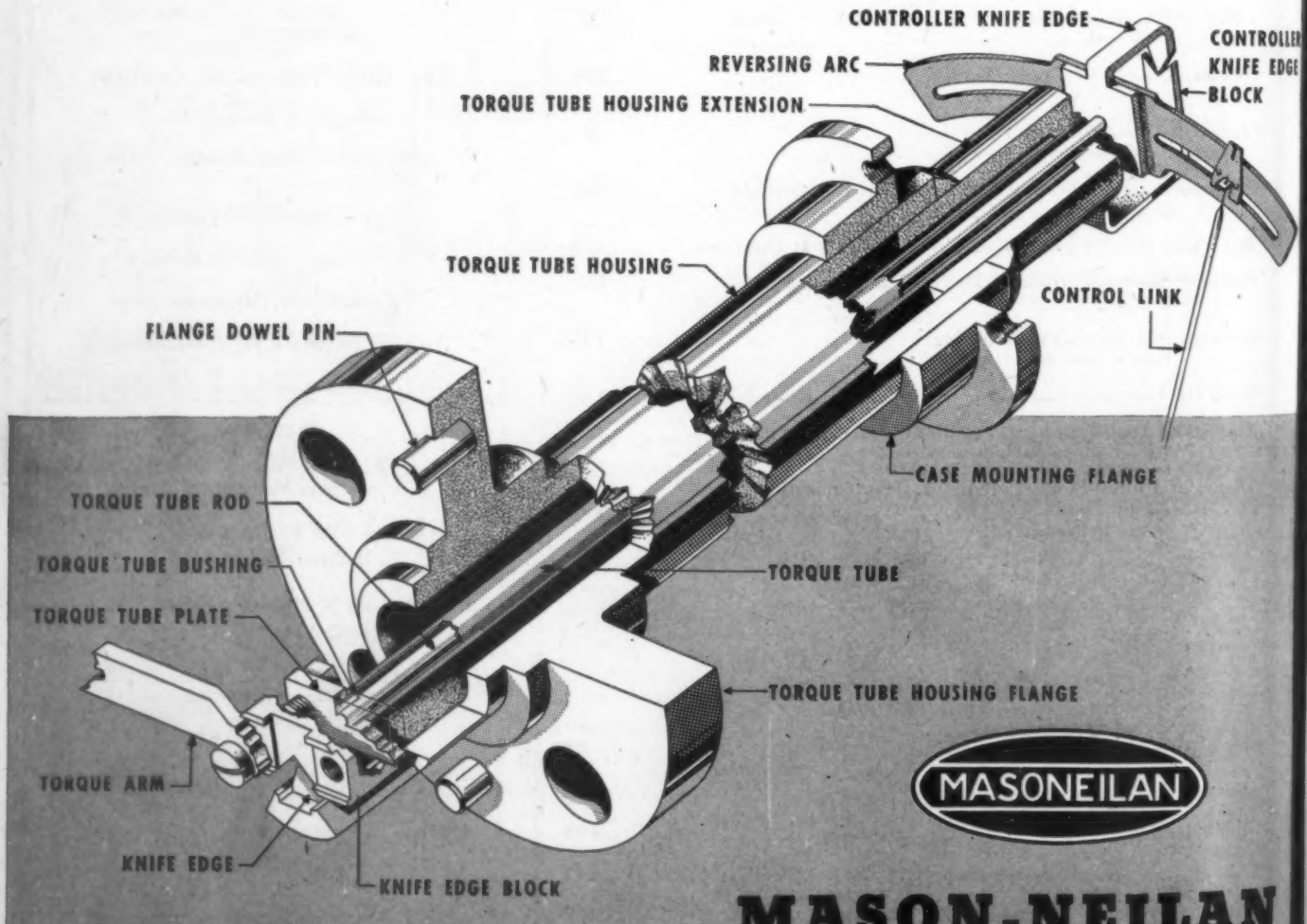

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REFINER

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THE LOOK BOX

ONE OF the repulsive pieces of national legislation gave FEPC legal status. By it the necessity of war production is used to enforce what a few men consider racial fairness in employment. Its workings are responsible for tension and bitterness in some refining plants today.

In All Fairness

FEPC is not fair to the corporation. Through it, the corporation is directed to advance certain employes, usually Mexicans or negroes, few of whom are concerned about the advancement. If the management complies, its older and competent workers go on strike or get ready for a strike. Still the management has no choice. Unless it upgrades the individuals, it has violated a federal law in time of war.

If the action brings on a strike, vital production is halted in time of war.

Meanwhile a hundred men who left that plant for military service face the prospect of returning to former jobs and finding men of other color and often of questionable ability in supervising positions.

It would be well if the writers of bills to impose fairness gave the word long study.

"With the facilities for mass production, this country became dedicated to the proposition that it is better to manufacture and sell things to millions, rather than to a very few."

—L. C. WELCH, *Director,*
Sandard Oil Company (Indiana).

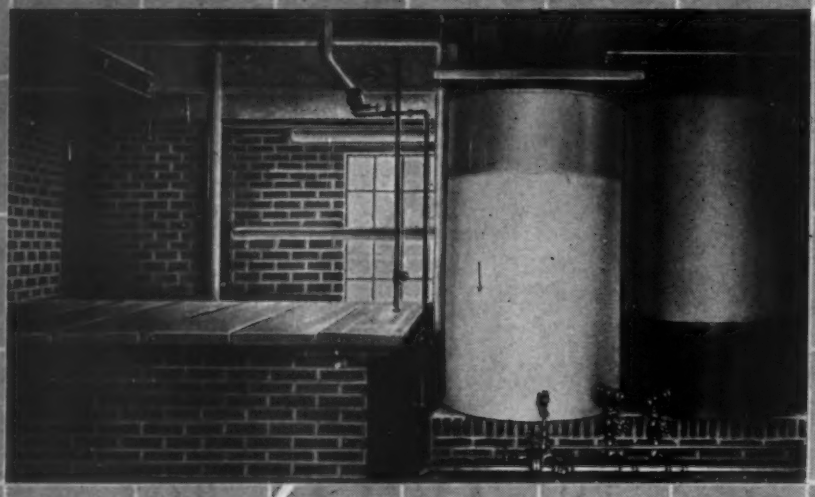
THERE is something abhorent in the prospect of devoting any of the energy and resources of this country to the provision of gasoline for civilian use in liberated countries. The proposal comes at a time when the holders of A cards have been given some encouragement that another gallon of gasoline per ticket may be permissible after VE day. This would indicate only a trivial increase in available motor fuel, come the end of fighting in Europe.

And Besides That, Why?

Still the Petroleum Administration for War has asked the Foreign Operations Committee of the industry "to be prepared to assist in handling the petroleum supplies for civilian Europe when the United Nations military forces relinquish the responsibility and so long as wartime product and transportation shortages exist." In another communication he has asked Orville Harden, chairman of the Foreign Operations Committee of the oil industry to name a sub-committee—the North American Supply and Distribution Committee—and "to revise its responsibilities so that it can participate actively in supplying North Africa as soon as the military situation permits . . . "

This has the ring of placing this country and one of its dwindling resources in position to take care of civilian gasoline needs for a long, long time. Even when the military had authority over gasoline distribution in its occupied areas, it was remarkable how much of its gasoline came into private use. Letters from soldiers in North Africa

Dowtherm on the job!



Trouble!—Till Dowtherm Brought Safety . . . Accuracy . . . Speed

This Eastern concern had trouble aplenty! Processing special greases and core oils, they were continually plagued by charring kettle bottoms—plus the constant fire hazard of their heat transfer system and highly combustible materials in the plant.

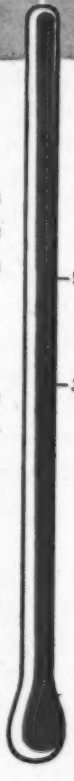
That was before they installed Dowtherm!

For eight years now Dowtherm—the high-temperature, low-pressure heat transfer medium—has been giving this company efficient, positive heat control. It has proved a speedy, accurate *multiple tool* in the 350-500°F. range at which various high-temperature operations turn out the firm's different products.

This Dowtherm unit is performing as effectively today as the day it was installed—*with its original charge of Dowtherm fluid.* Only small quantities have been added for make-up from time to time.

"We're completely sold," says the plant superintendent. "Naturally we've had some maintenance, but Dowtherm is doing the job. We've recommended it to a lot of other people."

Dowtherm is doing a similarly effective job for hundreds of other users who require precise heat control in a broad temperature range up to 725°F. For product uniformity . . . reduced maintenance . . . speedier production—look to Dowtherm.



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mentioned it so frequently that its truth cannot be doubted.

Now it would seem that with military operations completed, civilian support must be given to what was obnoxious even during military occupancy.

Although the move is a request from a governmental agency to a committee within the industry, the news release from PAW includes "that it operate with respect to such European areas as from time to time are indicated by PAW." Further, the committee will be called upon to compile data on authorized supply programs and to help arrange for transportation of products in accordance with such programs."

If the Petroleum Administration has authority for extending its activities into foreign fields, that authority has been granted since the agency was set up in June, 1941, under Harold L. Ickes as Petroleum Coordinator for National Defense. who was charged with "insuring that the supply of petroleum and its products will be accommodated to the needs of the nation and the national defense program" and "that petroleum and its products be made available to meet military and civilian needs."

Several readings of that letter have failed to reveal any authority by which PAW can extend its activities to foreign civilian gasoline needs. This is not to deny that such authority exists. There have been many letters and many directives since June, 1941.

Even with authority the wisdom of such action is questionable. Only a philosophy that ignores history and human traits can support programs of undertaking to provide the unfortunate people of Europe with more than bare necessities. Somewhere and somehow the peoples of Europe, even those who had no part in the fighting, must of their own volition undertake to provide what they need. The school children of this country know that men walked away from the battlefields of the War of the Revolution as they did from the battlefields of the War between the States and took up life with whatever they could acquire. Those were not desirable periods. But what took place in those periods was part of the cost of building and rebuilding a nation.

That gasoline will be required in restoration of Europe is certain. Through lend-lease, authorities in these countries will have access to fuel supplies. The Red Cross can assure some moter fuel for pressing civilian needs in Europe. There is no quarrel with providing bare necessity for restoring governmental functions.

But the proposition of PAW setting up another approach, whose objective is petroleum products for European civilian uses is simply beyond comprehension. It smacks to much of improper application of facilities that came into existence for one purpose only—winning the war.

Individual Security

ONE of the discouraging trends in science is evidence that men of unquestioned technical training are bent on careers in which something is provided for them. They are coming into industry in quest of what can be done for them instead of an assurance of what they can do for themselves. The attitude is not restricted to men with technical training, for the demand for security is widespread.

The schools may be at fault. It is regrettable if teaching is on the one hand preparing men to widen the horizon of useful things, and on the other hand warning them to demand security, however wide the horizons. It is equally regrettable if along with scientific training men are not being assured that the training itself is the best security the individual can have.

However attractive security may be from the viewpoint of comfort, it is an opiate. Energy and ingenuity do not thrive on security.

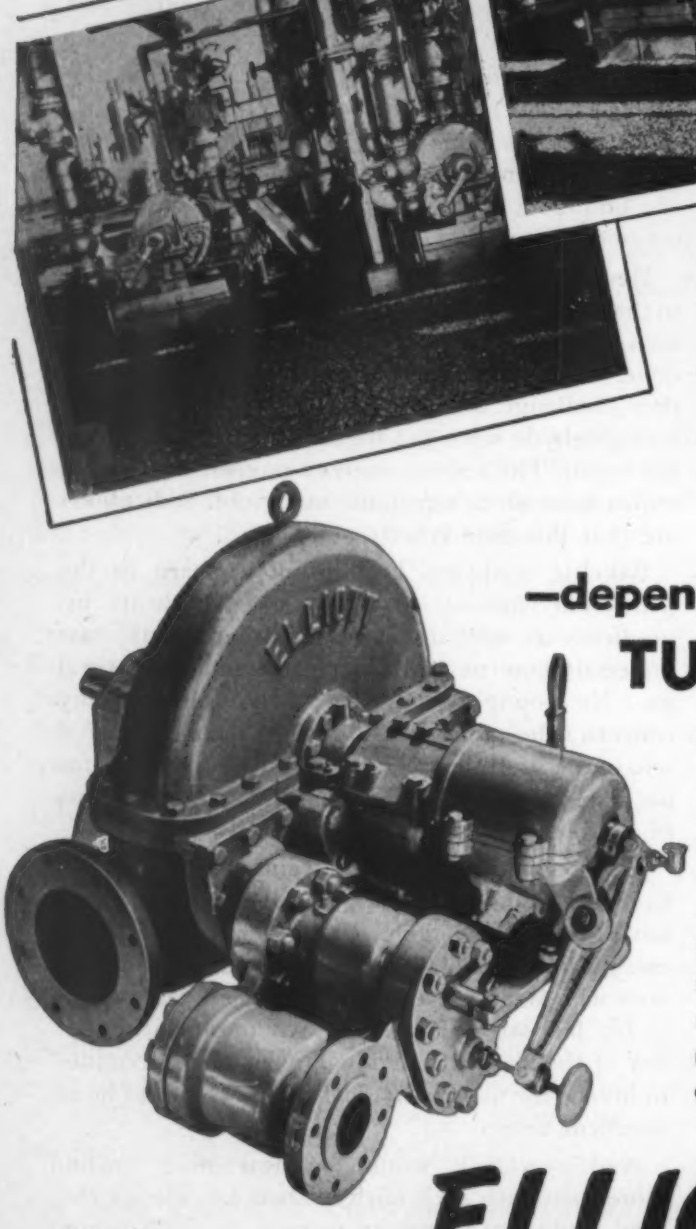
The false philosophy that the machine is the enemy of man may be responsible for the attitude of security seeking. This philosophy can not be charged to our schools. Its dictums have come out of a branch of economic study as well as from government, even labor.

Men with scientific training should give no heed to that philosophy. The record shows that the more men invent and accomplish the more there is to be done. Invention and the machine do not bind men; they challenge men. A few years ago phenol and formaldehyde were put together and Bakelite was the result. The success revived interest in plastics, which have since expanded manyfold. Indications are that this field is only starting.

Bakelite doubtless brought no concern to the petroleum chemist. Now, however, both its ingredients as well as scores of other plastic raw materials may be had from petroleum or natural gas. No young chemist need give security any concern if he can contribute to the development of what the petroleum industry will provide for plastics. There are scores of similar attractive spots in petroleum chemistry.

What scientific training seems to lack is the flavor of doing something for itself, rather than having something done for it. It would be heartening if our schools were turning out more young men who were not even interested in secure jobs in big laboratories and research organizations. A few of the rugged individuals who are determined to invent for their individual accounts would be an excellent tonic.

And overall it would be heartening to find more men with such faith in their knowledge that they could leave security to take its place behind accomplishment.



—dependable mechanical drives in TURBINES *by* ELLIOTT

Almost anywhere the camera clicks at this big cycling plant, it will disclose one or more Elliott mechanical drive turbines. Those in the photos are driving pumps. Others, not shown, drive forced-draft fans. The Elliott turbines at this vital Texas Company plant range in capacity up to 360 hp. Because there are so many of them, you can safely assume that they enjoy the fullest confidence of the Erath plant engineers just as they do at natural gas plants and refineries generally, where Elliott turbines, direct-drive and geared, are in wide use.

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H-691

Management from the Superintendent's Viewpoint

O. B. WENDELN

FOR too long the industry has looked upon the plant superintendent as a man responsible for routine operation of a plant. Instead his duties are more extensive. His viewpoint is similar to that of the executives of his company. He must make decisions that involve personnel; he must decide when a service should be discontinued.

In this article a plant superintendent sets forth the viewpoint from which the plant manager must weigh and consider the problems that are common to keeping cost of manufacture within proper bounds. It gets down to frequent estimation of functions of routine duties. Frequently the question must be asked "Is it still necessary?" Otherwise routine duties will persist long after serving their purpose.

It should be noted that Mr. Wendeln acknowledges that it is well for this attitude of the superintendent to be instilled in the attitudes of assistant superintendents and foremen. These men, too, have their management problems. When they become imbued with a desire to keep costs down, favorable results follow.

These observations are being printed in two parts and the second will appear in the June, 1945, issue of PETROLEUM REFINER.

THE composite objective of executives in the petroleum and other industries in these present times, is to vigorously reduce expenses to the minimum necessary for intelligent operation, and to ruthlessly eliminate costly inefficiencies, not only to perform a better job in wartime, but also to enable the company to maintain its existence in the postwar period.

A great deal of study has been given by the petroleum industry to the efficiency of its marketing operations. The excessive number of retail outlets have been subjects of considerable adverse publicity.

Decidedly less emphasis and publicity has been given the manufacturing or refining phases of the petroleum industry. Needless to say, inefficiencies do exist in these departments. If it were possible to cover some of the major possibilities of cost reduction in the manufacturing phases of the industry, and if the items included were such that not only executives, but also foremen, supervisors and workers would obtain an incentive to eliminate costly inefficiencies, additional benefit would result in the war effort.

With this in mind, specific suggestions will be summarized and commented upon below, as to routes of attack on the problem of cost reductions. The goal is not the location of self evident possibilities, but those which are partially hidden; is not to reach only the head man, but to get each worker in the organization to think; is not to apply only these specific suggestions, but to use them as accelerators for other ideas. All of these goals are for the purpose of performing a better job in wartime, and enabling the company and workers to maintain their position in the postwar period.

It is necessary to know what is accomplished from the use of the various methods of attack on costs, to determine whether increases or decreases have resulted. Sustained interest in effort to decrease costs can be maintained by use of indexes, either on a total dollar per period basis, or dollar cost per unit of raw or finished material.

An index as used herein might be defined as a sequence of figures presented numerically or preferably graphically to reflect certain conditions, operations, circumstances or costs, for the ultimate purpose of acting as a guide of the variables causing the fluctuations of the index, and as a control to cause them to remain steady or be increased or decreased at will.

Indexes on overall costs, and overall costs per unit are necessary for revealing information, but ordinarily they cannot be used to permit corrective steps and reductions in costs. It is necessary to use indexes of the details which go to make up the overall costs, which can actually be used to guide the foremen in their daily procedures and decisions. Each index so used should be sufficiently important from a dollar-and-cents basis, to warrant the individual index being followed, and proof be available for substantiating its economic status. This proof should be boiled down to an abbreviated "rule of thumb," presented in units of sufficient magnitude to make it an impressive figure, and be kept constantly before the individual using the trend of the index.

All too often, considerable time and money is spent in compiling data and presenting indexes, but no actual corrective steps are taken to improve the situation reflected. If such be the case, the advisability and necessity of the preparation of the data is questionable. All too often overall indexes are presented, but the items of lesser magnitude which go to make up the overall picture which are actually the controllable features, are not given consideration or used; or they are not given to the sub foremen who have power to actually reduce the expenses revealed in the indexes.

A few general basic indexes will be mentioned which might be used, in the hope that others will suggest themselves:

Physical tests reflecting completeness of separation of finished products.

Loss of raw material in processing, either in percentage or dollar basis.

Consumption of supplementary raw material per unit of charge or production.

Overall man-hour expenditures and experience per unit of charge or production.

Cost of overtime on dollar basis, both monthly and cumulative yearly.

Consumption of utilities.

Man-hour experience per unit of volume handled for miscellaneous departments, where volumes are variable.

Time efficiencies of machines or units, per period.

Combustion efficiencies or percentage fuel per unit of raw material or product, where dollar value fuel consumed is of sufficient magnitude to so consider.

The above suggested items are a few of the many possibilities. It is emphasized that as listed they are generalities, and require further breaking down to be of actual efficient use. Losses in processing for instance, requires a break down to individual producing units where possible, as well as does combustion costs to individual fuel-consuming units. Again, let it be repeated, the index's dollar importance must be established; it must be boiled down to a rule-of-thumb dollar cost; its preparation must not be costly; and the index must be actually used as a corrective means, or discontinued entirely.

Elimination of Unnecessary or Uneconomical Routine and Services

The importance of elimination of unnecessary or uneconomical routine and services cannot be overemphasized. Procedures which were fully required at the time of their inception frequently are outmoded with the passage of time, but are continued year after year to provide a function for some individual, even though the results may never be used. It is most difficult to unearth these items, as ready answers for reasons as to why they should be continued are forthcoming.

One means of getting down to bare essentials of necessary work is to arbitrarily reduce the personnel in each classification, until production and maintenance necessities can just be handled, and then gradually build up those classifications in which there is definite proof as to economic advisability of additional personnel. This has the advantage of getting the effect quickly, and perhaps saving of certain dollars which otherwise would have been expended. It has the disadvantage of temporary lowering output, and lowering of maintenance standards below their economic minimum.

One other means to accomplish the same end is gradual elimination of unnecessary routine and services by study, planning and thought as to ways and means to reduce the dollers expended. This has the disadvantage of the longer time element, without the disadvantage of lowering of standards. But if those individuals responsible are thoroughly sold on the ultimate aim and necessity of minimum costs, greater strides and goals can be attained, including the retention of those individuals in steady employment who can be used, by thoroughly canvassing each and every possibility of each dollar expended.

There can be no fixed set of rules or procedures, whereby this basic investigation can be applied. It is necessary that each operation be studied, whether it be in the processing, maintenance, service or recording departments, to establish the origin, whether efficiently handled, and the necessity of present use.

Although no standard rules can be applied to guide an investigation of this type, there are some typical routes common to most industries, which are worthy of mention and emphasis. They will be covered as concrete suggestions, to act as guides, so that additional possibilities will come to mind.

The work of the maintenance department warrants careful check to determine minimum personnel requirements, advisability of contracting some of the work, particularly that of peak loads, and whether the work being done is in the "necessity" class, or in the just "desirable" group but is being completed regardless of being so classified. Scheduled but unstarted work should be periodically reviewed to establish whether conditions have changed to permit its cancellation, and still maintain the necessary production.

The inspection of material being processed and finished, usually a function of the laboratory division, is very liable to be over-controlled and very difficult to discontinue, when once established in the daily routine. A comprehensive study of each sample, its frequency, the scope of the tests, will usually reveal a 25 to 30 percent reduction possibility. These reductions do not necessarily result in extensive spoilage and off-specification material, as "necessity is the mother of invention," and other means of control are found which do not involve the former expense.

A great deal of time is spent in accumulating and preparing a maze of tabular data. Top management and even department heads frequently are not aware of its extent. A perodic complete survey of tabular data on a routine basis in all departments is justified to establish the necessity of each item, and whether the most economic procedure is being followed.

The word complete as used above, means all inclusive. It will be found, when the call is made for this routine data, that it will be difficult to obtain a complete survey. The various individuals involved will feel that this work sheet, or those figures do not take much time, and hence are not worthy of consideration. Study of an individual report as to its necessity and advisability are usually not uncommon in organizations, and that item which is outstanding and not being used at all is discontinued. The purpose of a survey of this broad nature is to catch those hidden items which are not so obvious, of which there are usually numerous ones.

This study would not necessarily mean that the major portion of this work could or should be discontinued. A majority of the items probably will be justifiable and should be approved. Other items or procedures in preparation of the information will be questionable. These questions fall into general classifications, applicable to all of the routine data submitted for study. It might be of interest to list a few, to act as a guide.

Does anyone use the information after it is prepared? Does anyone do anything to change or correct procedures based on this information, after it is observed?

Is this information a matter of convenience, matter of advisability, or a matter of necessity?

Is typing of the data essential, or will pencil copies be adequate?

Can the number of copies distributed be cut down, to avoid making more than one run of the report?

Are typed work sheets being used to permit insertion of the new data? Could previous reports be used as work sheets instead, to effect the savings which might be involved?

Is the data properly presented, to facilitate grasping of the general situation?

Is this data already presented elsewhere, the use of which would eliminate the necessity of the preparation of the item under consideration?

Is somewhat similar data being presented elsewhere, the presentation of which could be combined to advantage?

Is the preparation, presentation and handling of this data, quite different than normal procedures, which normal procedures are assumed to be the most efficient, and should this particular item be standardized?

Can procedures be reduced by just checking off the data presented, instead of the necessity of recopying certain information?

Is this data being prepared by the proper individual and department? Should a foreman, clerk, or plant worker be handling its preparation?

Is the data being prepared at the proper place or department, to make it readily available for actual use with minimum difficulty?

Are the work sheets necessary, or can the data be prepared in its final form direct from the source of the data?

Even though the report as a whole may be usable, necessary and economically advisable, can portions of this data be discontinued without affecting the reports utility?

Can the information be presented, using the source of the data (for instance, individual slips or reports), without the necessity of summarizing the same?

Can the frequency of the report be reduced? Can a seven-day-per-week report be reduced to five per week, with Monday covering 72 hours? Can a five-day-per-week report be reduced to three per week? Can a weekly report be reduced to a monthly report, and still not lose the advantage of necessary information?

What is the measure of importance of this form? Does this information act as control over expenditures of $10.00 or $10,000.00 per month?

If the information and procedures involved in each work sheet, memo or forms can withstand a barrage of questions of this nature or of similar scope, and come out with an honest high rating, each item so considered should be necessary and economically justifiable.

Arrangement of Information and Data in Sequence of Magnitude

Arrangement of information has applications which may bring out a great number of channels of thought, which otherwise probably would not be brought to light. As this procedure does not lend itself readily to citation of specific rules, concrete examples will be given showing previous uses, so that they may suggest similar cases and applications.

One use is in connection with the overall expenses which are customarily grouped into 10 or 15 different types of general classifications, such as labor, fuel, materials, purchased services, etc., for the purpose of facilitating observation of trends of these components. Periodic numerical or graphic arrangements of these groupings in sequence of magnitude on a dollar or percentage basis will focus attention on the important items, to permit concentrated thought upon means of lowering those expenses of greatest magnitude.

A specific example of this application focused attention thereby to the fuel expense. It was found that this was an item of major magnitude, in fact at times exceeding all other types of major expense classifications. This resulted in concentrated study as to furnace efficiencies and heat-exchange equipment, as well as the establishment of indexes to follow trends and procedures to provide daily checks upon conditions. The magnitude of the expense involved in dollars warranted considerable expense in maintaining peak efficiencies, but in the example in mind, the checks and procedures were handled without involving additional labor.

In another instance a request was made to make a list of all possible fuel economy items, and to arrange them in sequence of probable dollar savings on a monthly basis. This listing then served as a method of attack upon the overall problem, using the items of greatest magnitude as a starting point. This same principle can be applied to many other types of expense.

A further means of attack is to arrange the actual expenses in dollars on individual sub-departments in sequence of magnitude. The first ten or so items are worthy of further investigations, in effort to reduce their expenses, and are more worthy of checking because of their magnitude than those appearing near the bottom of the list.

To individually list the volumes of each point of consumption or distribution of utilities such as steam, air, water and electricity in sequence of magnitude, provides a tool worthy of consideration in attacking reduction of dollar expense in these. The lack of equipment to measure or estimate these volumes usually will be the stumbling-block of the attack on this problem. But it is not unsurmountable, and it may be found to be economically sound to provide measuring equipment to some degree.

Time As An Element of Cost

There is an important time cost phase involving those industries wherein the major portion of the plant or department consists of one or more relatively large semi-continuous processing units, requiring extensive costs at the end of each cycle in repairing, maintaining, cleaning and putting the unit back in operation. The interest on the investment continues while the unit is down, production is not consummated, and peak man-hour-load requirements are found necessary to place the equipment in usable condition. Anything which can be done to lengthen the operating cycles and decrease the length of cleaning time is an improvement. A systematic study of this problem will bring out possible economies.

It frequently is essential to maintain records of the causes of shut-downs and the past history of operating cycles of major equipment, to act as a guide for future improvements. If these shut-downs are broken down and listed as to basic causes, eliminating resultant effects, corrective steps and their economic effect can be studied and considered. Basic causes may be grouped perhaps under operation, maintenance, or even personnel attitude.

Proper Coding of Various Charges

The study of the final cost statements will reveal many charges which appear out of line. As it is very desirable to have these charges where they properly belong to permit subsequent reduction, the question resolves itself into ways and means of bringing these items to light. If the responsibility for dollars spent in each sub-department are assigned to each subforeman, it will lead to intensive study of each dollar charged to that particular department. These careful checks tend to correct or uncover any improper charging.

It is suggested that dollar charges per period be converted back into units charged per hour, which can be compared to known figures to determine if they are unreasonable. For example, dollar charges of fuel on a gas-driven compressor could be converted into cubic feet consumption per hour, and be compared to the manufactures rated consumption; the same to apply to steam, electricity, etc.; labor charged can be compared to manhours actually used for a job or department per period.

If all of the details of a particular type of expense are tabulated for all departments so charged, and summarized, the study of this information by informed parties may lead to known similar expense in departments which were not properly charged for the same. The follow up on this will develop correct procedures.

Upon receipt of a shipping order, some organizations get it out immediately regardless of the cost involved in overtime, power or other costs. This can be avoided by proper planning, and cooperation of the

sales departments, and still meet all the requirements of the customer. This rapidity can be of a major cost consequence.

It is advisable to check not only the procedures in handling the shipment of major products, but the handling of sample orders as well. There have been occasions where emphasis has been placed on this type of order, involving expenses out of proportion to the necessity of the same.

Shipping arrangements and schedules are likely to be disrupted if working inventories of finished materials are consistently carried at abnormally low levels. Low inventories may involve uneconomical operation, particularly in those industries processing fluid materials, in that minor variations in the production are likely to reflect in the finished product, necessitating a greater safety factor for quality. This is costly and should be avoided. Furthermore, the customer is likely to insist on the higher quality at all times, once he is accustomed to the higher safety factor for quality. The other extreme of excessively high inventories are disadvantageous in that additional money is tied up in the products which might be used to better advantage elsewhere.

Low inventories of stores material, current tool and supplies might fall into this same category. This is a special subject which has been given a great deal of thought, and covering which there are a number of indexes and file systems on the market to assist in this problem.

Increased Throughput or Output, and Its Effect on Cost Per Unit

If additional consumption or production can be effected with the same piece of equipment, the cost per unit will be lowered. This is primarily true because fixed charges do not necessarily increase in proportion to the increased throughput or output. The increased throughput need not be effected resultant from what is commonly called the "speed-up," but it can be effected by proper planning, time scheduling, and checking into the possibilities. Just a few of the routes of attack on this problem will be suggested:

Reducing the period of downtime on each unit, by detailed study and correction of the bottle necks of each job which keeps the unit off the production line.

Installation of stand-by equipment on those items of importance where difficulty is likely to be experienced, provided the economics can substantiate the necessity or advisability of such a move.

Production and sale of by-products at a profit, which can be handled with the equipment, without materially effecting loss of production of the major necessary product. This in turn will increase the consumption of the overall raw material, and will effect reduction in cost per unit.

Alteration of operating conditions of the equipment, so that volumes consumed will be greater. This may be accomplished without "speed-up" as far as manual labor is concerned, in those industries utilizing heat, pressure and time elements in their manufacturing. An increase in temperature for instance, may increase production, but in turn, it may have its effect in reducing yields, length of cycles and other variables. An economic balance must be established.

Use of facilities already in part or wholly existant for purpose of service or production, to outside or subsidiary concerns, to manufacture, service or handle auxiliary items. These may or may not be similar to the principal product or principal service, but in most cases are found to be somewhat related in characteristics. It would be assumed that these items would be handled at a profit, and benefit the overall costs. A concrete example of the above in the oil industry is the storage, handling and terminaling of crude oil for an outside or subsidiary company, using the existing equipment.

The above suggestion involves furnishing services or products to other concerns. The converse of this may be equally profitable in that costs might be reduced by purchase or rental of facilities from the neighbor to avoid capital investment outlay, or merely because the item can be obtained more economically. These items might cover utility services which are waste or excesses, shop facilities, or even the use of idle equipment. There are disadvantages to this, in that too much dependency has to be placed on the operations of the neighbor over which there is but little control. If it is profitable to both parties concerned, the dollars savings may outweigh the dependency involved.

Losses and Wastes

The petroleum industry probably is more fully aware of loss and waste phases of cost than any other item. The whole subject of cost reduction is a matter of elimination of dollars lost. Covered below are some of the phases of losses, listed for the purpose of accentuating their importance.

In some industries, losses of material in process and storage can be labeled as scrap; in others, particularly those handling fluid as a raw material such as oil refineries, there is actual raw material or finished material loss.

Another type of loss involves the converting of a portion of the raw material into products or by-products, having a dollar value less than the principal product desired. Unless the percentage yield of the principal revenue product is maintained at a high figure, actual dollar losses may be experienced. There are possibilities of developing uses of the less expensive by-products, so that their value is increased, thereby minimizing the loss in question. Usually the direction of this phase is not within the scope of the manufacturing establishment, but is assigned to experimental laboratories.

Scrap, as such, warrants its study to be assured that maximum returns are obtained therefrom, and that none of it is not accounted for. Frequently reclamation departments are set up to control this, or convert portions of it into usable material.

The use of percentages and indexes of trends is well warranted in following losses, keeping in mind dollar values of these controls. This applies whether scrap be involved, or loss of raw material.

The greatest laxity in following and correcting losses is the neglect to break down the overall loss into sufficient detail to permit actual control and improvement. In the industries with fluid raw material manufacturing more than one principal product, controls should be established to guide the separation between most products. The same can be said of scrap from each point, in other types of industries.

Included in the catagory of losses of supplementary materials are chemicals and other items of magnitude, not directly entering into the finished product, but necessary in the handling, manufacturing, or processing of the raw material. The biggest loop hole in this type of expense or loss is that frequently the supplementary material is either over-consumed or under-consumed, i.e., an excessive quantity of chemical is used, or the chemical used is not completely used up prior to being discarded.

Adequate checks should be established to avoid these types of consumption. It should be determined if there is any further use of this material upon completion of its present use, and whether adequate indexes are in vogue to control and note improvement. If the dollar value of the item in question over a period of a year is of sufficient magnitude, it should warrant additional checks.

The services under the grouping of utility losses

are usually of magnitude on a dollar basis in industry. All too frequently, concentrated thought is devoted to the production or use of these, with but little effort being made on the conservation of the same with the exception of the outstanding items. It is not desired to convey the thought that this is entirely neglected, but frequently there is no specific program set up to eliminate utility losses, nor an index established to reflect that which has been accomplished along this line, nor what it means in dollars and cents reduction in expenditures. A few of the possibilities in utilities will be listed:

Steam

Eliminate actual leaks of steam to the air.

Minimize radiation losses, due to improper insulation. Figure the heat loss cost in dollars of 1 foot of 2-inch uninsulated 125-pound steam line exposed to the atmosphere for one year. The figure will be amazing.

List and eliminate points where high-pressure steam is used for heating purposes, assuming that exhaust steam is available for heating.

Be assured that there are no leaks between high-pressure and exhaust steam systems.

Shut off dead end steam lines not in service.

Locate and repair inefficient steam consuming equipment.

Obtain good water supply for boiler-water treatment.

Minimize blowdown requirements in boiler equipment.

Study boiler loads to keep to uniform load if possible.

Electricity

Establish location of voltage losses and correct.

Compensate or correct for low power factor equipment, if dollar savings can be effected in the tariff.

Study light loads to determine if the lighting can be minimized.

Schedule and arrange loads to avoid peak demands. The dollar-saving possibilities of this one item is usually outstanding.

Water and Air

Correct actual losses to the sewer.

Eliminate continued use of water, particularly when the equipment has been shut down and the use of the same is unnecessary.

Lower pressure, if so doing effects a saving, and use of this lower pressure is satisfactory.

Fuel Losses

Locate and correct inefficient points of use. Include in this, consideration of all points where gases, fluids or solids are being cooled and the heat is not being conserved.

Use the lowest-price fuel or power possible, if the work can be handled with it. Use fuel under the boilers for steam power for instance, if it is more economical than buying electrical power.

Checks on Charges to Subsidiaries or Outside Vs.

Various services are started on occasion as minor gratuities, which over a period of years build up to major proportions, without any charges at times being involved. In other instances, lack of proper metering or measuring equipment is at fault. It has been observed in some installations even where proper metering equipment is provided, that it has been erroneously installed causing false charges to be made. Formal contracts covering services of this kind may even be in error, and warrant review to also determine whether conditions, loads and volumes have altered the situation since the original contract.

A few of the possible locations of dollar leakages are listed as suggestions to permit checking:

Rental of property.
Services to employes.
Telephone and telegraph services.
Electric power and light.
Water, industrial and drinking.
Steam, for power and heating.
Air.
Miscellaneous clerical services.
Miscellaneous shop services.

Comments will be made on only a few of the above items. Rental of property is worthy of check to establish if a fair return is being received; if maintenance is excessive; and just what items are normally included in maintenance and extra services, with the thought in mind to attempt to reduce the cost of any items which cannot be justified.

Services to employes is on occasion a costly and misused gratuity. The element of personnel relations enters into this problem. If it can be kept to a minimum, it has some merit from this angle on occasions. The details of what these services might be, will not be entered into, as each organization should be aware of the scope. The present suggestion is that the dollars cost be tabulated for a period, including labor, burden, material, whether new or used, and due consideration be given to this tabulation as to the advisability of continuance of the practice.

In all of the services to outside concerns, consider whether a stand-by charge is justified. In some cases loads are normally light, but on occasions are excessive, requiring equipment and capacity to be kept in readiness to handle the situation. Under these circumstances stand-by charges should be thoroughly justified.

Similarly consider load and demand factors, particularly in electrical purchases. Determine whether the charges are adequate to compensate for increases in the overall billing, under the circumstances where a portion of the purchases of electric power is being resold.

Establish whether burden and overhead are included in all of the charges for services, and if the charges completely cover the costs involved. If the service were to be discontinued, would the expense to the primary manufacturing plant be reduced? A specific example might be telephone service through a switch board to a subsidiary organization, which required an exclusive night trunk line. In this case the subsidiary should stand full charges on the trunk line, if it is not essential to have this extra trunk line as far as the primary plant is concerned.

Checks on Charges For Purchased Services

Charges for purchased services vary with each manufacturing unit. It might include utilities purchased, but it also might cover rental expense, auxiliary shop expense, and the like. Overall it is likely to be of magnitude and warrant careful study.

Each contract or tariff covering should be carefully scrutinized to determine if all clauses are justifiable. Most tariffs or contracts have clauses permitting certain savings if certain conditions are met. Study should be made whether those savings can or are being effected. For example, this is particularly true of electric utility contracts, where demand charges are involved. Resultant from the installation of demand alarms and re-scheduling of loads, major savings have been effected. Excessive electrical demands have been known to nullify all the profits derived from a special operation. Purchased service, particularly utilities, usually involve "new money" or cash out of pocket, and hence the daily consumption should be carefully watched. Where volumes of cash outlay justify, some individual should be charged with that responsibility, and actually study and follow the item daily to minimize that dollar expense.

Possibility of savings by lowering the power or pressure of the utility should be considered.

The concluding part of this article will appear in the next issue.

Production of Synthetic Liquid Fuel from Natural Gas*

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THE synthesis of hydrocarbons from carbon monoxide and hydrogen mixtures is a problem of primary importance in our national war and peace economy. The versatility of the process, the variety of the products and the mild operating conditions are the attractive features of this synthesis. It is in the interest of gas and petroleum industries to study, develop and improve the methods of catalytic conversion of carbon monoxide-hydrogen mixtures to hydrocarbons.

The gas industry can find in this method:

a. A means for upgrading the gas.

b. A new use for gas.

c. An enrichment of water gas independent of petroleum.

The petroleum industry creates a new potential supply of liquid motor fuel equal to at least half of known petroleum resources.

The synthesis of hydrocarbons from carbon monoxide-hydrogen mixtures is based on the catalytic reduction of carbon monoxide by hydrogen, known as Fischer-Tropsch reaction, and proceeds according to the following equation:

$$X\ (CO + 2H_2) \longrightarrow (CH_2)_x + XH_2O \qquad (1)$$

In the above equation X depends upon the conditions of the reaction and the entire series of hydrocarbons from methane to paraffin wax is usually received.

Thus 1000 cubic feet of synthesis gas (33.3 percent) carbon monoxide; 66.7 percent hydrogen) theoretically will give approximately 2 gallons (12.3 pounds) of hydrocarbon material. Actually, however, incomplete reaction and gas formation reduce the yield of product. In practice, the yield of hydrocarbons, other than methane, ethane and ethylene, is 1.4 to 1.5 gallons (9.5 pounds) per 1000 cubic feet of synthesis gas.

The so-called synthesis gas is a mixture of one part carbon monoxide and two parts hydrogen by volume. The flexible nature of the Fischer-Tropsch process is evidenced by the fact that any carbonaceous material can be transformed to carbon monoxide-hydrogen mixtures by suitable means. It means that our coal reserves guarantee an internal source of hydrocarbon fuel for many centuries.

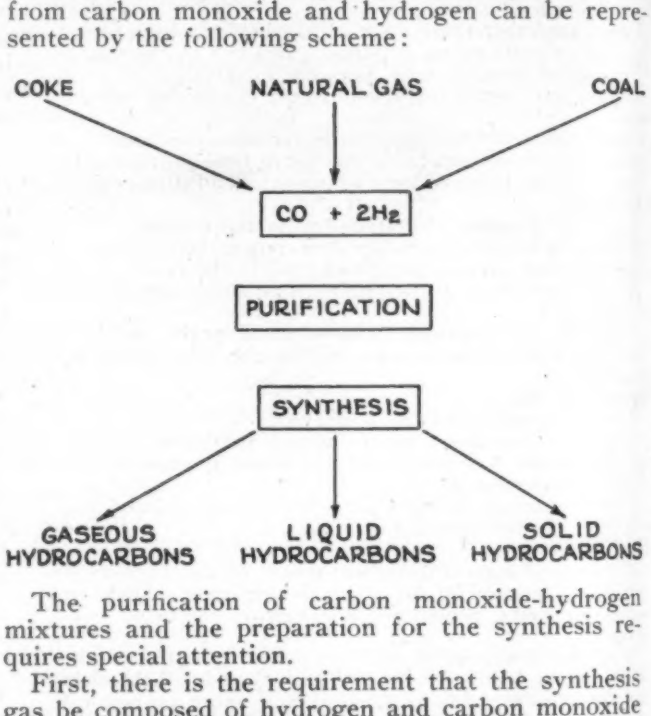
Natural gas can be easily converted to a synthesis gas by a number of reactions such as:

$$3\ CH_4 + 2H_2O + CO_2 \longrightarrow 4CO + 8H_2 \qquad (2)$$

$$CH_4 + \tfrac{1}{2}\ O_2 \longrightarrow CO + 2H_2 \qquad (3)$$

The proved reserves of natural gas in this country has been estimated at 100 trillion cubic feet. If an 85-90 percent conversion to synthetic gas is obtained, the total natural gas reserves could be converted into about 9 billion barrels of high-grade synthetic oil by present methods. Since the proved crude-oil reserve in the United States is about 20 billion barrels, it is evident that the conversion of natural gas to synthetic oil is an important consideration.

The basic steps in the production of hydrocarbons from carbon monoxide and hydrogen can be represented by the following scheme:



The purification of carbon monoxide-hydrogen mixtures and the preparation for the synthesis requires special attention.

First, there is the requirement that the synthesis gas be composed of hydrogen and carbon monoxide in the ratio of 2:1 for the industrially developed cobalt catalysts. This is occasioned by the nature of the reaction (Equation 1). Processes have been developed which can produce synthesis gas from a wide variety of materials. The production of synthesis gas from natural gas by means of steam gives a ratio of 3:1, i.e.,

$$CH_4 + H_2O \longrightarrow CO + 3H_2 \qquad (4)$$

The use of carbon dioxide (Equation 2) or oxygen (Equation 3) produces gases of the proper composition.

The second requirement, which has proved a considerable obstacle to the progress of the synthesis is the necessity of an absolute absence of sulfur in the synthesis gas. The upper limit of sulfur concentration which can be tolerated by the active catalyst is approximately 0.1 grain per 100 cubic feet.

The problem can be solved in one of two ways: (a) by means of desulfurization or (b) by developing a sulfur-resistant catalyst. The first method has been used almost exclusively since a sufficiently active sulfur-resistant catalyst has not yet been developed.

The products of synthesis are gaseous, liquid and solid hydrocarbons. The properties and specific composition of each depends entirely upon the catalyst

* Oil Industry in the War Effort discussion before Petroleum Panel, Chicago War Production Conference, March 29, 1945.

TABLE 1
Composition of Kogasin

	Percent by Weight	Olefins, Volume, Percent
C_3— and C_4— hydrocarbons	8	55
Gasoline (to 302° F.)	46	45
Naphtha (302–392° F.)	14	25
Diesel oil	22	10
Paraffin wax from oil [a]	7	..
Paraffin wax from catalyst [b]	3	..

[a] Melting point, 122° F. [b] Melting point, 194° F.

and other reaction variables, such as pressure, temperature, carbon monoxide-hydrogen ratio and the time of contacting of synthesis gas with the catalyst.

The following are the most important modifications of hydrocarbon synthesis from carbon monoxide-hydrogen mixtures.

Sabatier Synthesis

The conversion of carbon monoxide and hydrogen to methane was first accomplished by Sabatier and Senderens using nickel as catalyst.

$$CO + 3H_2 \longrightarrow CH_4 + H_2O \qquad (5)$$

This reaction could conceivably produce synthetic natural gas from coal. However, two major technical difficulties are encountered, namely, poisoning by sulfur and poisoning by carbon deposition. The latter is caused by a blanketing of the active catalyst centers according to the following reaction:

$$2CO \longrightarrow C + CO_2 \qquad (6)$$

The conditions favoring the production of methane rather than the Fischer-Tropsch synthesis of higher-molecular-weight hydrocarbons are: (a) catalyst, (b) relatively high temperatures, and (c) high proportion of hydrogen in the reacting gases. Nickel and iron catalysts are active at atmospheric pressure. The temperature required is about 570°F. for nickel catalysts. The ratio of hydrogen to carbon monoxide theoretically should be three (Equation 5).

It is of passing interest that carbon dioxide may be hydrogenated to methane at 570°F. over a pure iron catalyst. Ruthenium powder or ruthenium-thoria-asbestos may also be used for the production of methane from CO_2 at 212°F. However, after the initial step which is conversion to carbon monoxide and water vapor, the reduction proceeds according to Equation 5.

Kogasin Synthesis at Atmospheric Pressure

By using cobalt-thoria-Kiesulguhr (100:18:100) catalyst at atmospheric pressure and temperature of 375-390° F. the product of the following composition was obtained (Table 1).

The product is composed largely of straight-chain paraffin and olefin hydrocarbons with only minor amounts of aromatics, naphthenes or oxygen-containing compounds.

Table 1 presents data for the various fractions of the primary product when a cobalt catalyst was used. The gasoline boiling up to 392° F. constitutes 60 percent of the total product. Because of the straight-chain nature of the hydrocarbons in the product, the gasoline fractions have low octane numbers. Thus the octane number of the gasoline boiling in the aviation range (up to 302$_2$F.) was only 55.

The octane number of the gasoline and the total yield of gasoline can be increased by reforming and cracking in conventional petroleum-plant equipment. Thus, Egloff, Nelson and Morrell, by means of thermal reforming and cracking and catalytic polymerization of the cracking gases, received 84.3 percent of 66-octane gasoline from a Kogasin oil which, originally, had an octane number of 20 (Table 2).

TABLE 2
Processing of Kogasin to Produce Gasoline

	Yield* Volume, Percent
Light gasolin†	29.1
Reformed gasoline from naphtha‡	26.8
Cracked gasoline from bottoms	22.6
Polymer gasoline	5.8
	84.3
Octane number of blend of all gasolines	66

* Based on Kogasin oil charged; original octane number was 20.
† Octane number of 97-241° F. fraction was 68.
‡ Octane number of the 219-523° F. fraction before reforming was 4.

Diesel oil may be separated from the total Kogasin oil by simple distillation. It has a high cetane number due to the straight-chain character of the hydrocarbons contained in this fraction and is suitable for mixing with low-cetane-number oils.

The paraffin wax produced in the synthesis is similar to the product received from petroleum and can be put to the same uses. Since 1936 catalytic oxidation of the synthetic wax has been used for the production of synthetic fatty acids. The product consists almost entirely of saturated normal fatty acids of both odd and even carbon number, which are used for the manufacture of soap, cooking fats and artificial butter.

The Kogasin product as such does not contain any lubricating oils. To meet this need, methods have been developed in Fischer's laboratory to produce synthetic lubricating oils. Among those which have been reported are (1) polymerization of fractions rich in olefins with aluminum chloride; (2) chlorination of Kogasin fraction and polymerization without the addition of aromatics, and (3) alkylation of aromatic hydrocarbons with chlorinated fractions, according to the Friedel-Crafts reaction. Excellent viscosity properties (as shown by viscosity index of 90-100) are reported for these synthetic lubricating oils.

Middle-Pressure Synthesis

The industrial progress of the Kogasin synthesis was accelerated by the discovery of the "middle-pressure" synthesis by Fischer and Pichler in 1936. At pressures of 75 to 220 psi, an optimum yield of solid plus liquid hydrocarbons was received (Table 3). The chief advantage of this type of operation was that loss in catalyst activity was decreased. Whereas the yield dropped from 7.7 to 5.9 pounds per 1000 cubic feet in "normal-pressure" (atmospheric) synthesis in four weeks, the "middle-pressure" synthesis produced 8.9 pounds initially and still was above 5.9 pounds per 100 cubic feet after 26 weeks of operation. This synthesis has been performed with cobalt and iron (1937) catalysts; nickel catalysts deteriorate

TABLE 3
Effect of Pressure Upon the Yields* of Hydrocarbon Products (Yields expressed in pounds of product per 1000 cubic feet of gas at 60° F.)

Pressure Gauge p.s.i.	Total Solid and Liquid Hydrocarbons	Paraffin Wax	Oil Above 392° F	Gasoline Below 392° F.	Gaseous Hydrocarbons (Including C_3 and C_4)
0	6.9	0.6	2.2	4.1	2.3
22	7.7	0.9	2.5	4.3	3.0
74	8.9	3.6	3.0	2.3	2.0
220	8.6	4.2	2.1	2.3	2.0
735	8.2	3.2	2.2	2.8	1.2
2205	6.1	1.6	2.0	2.5	1.8

* Yields are average of four weeks operation over cobalt-thoria-Kieselguhr catalyst.

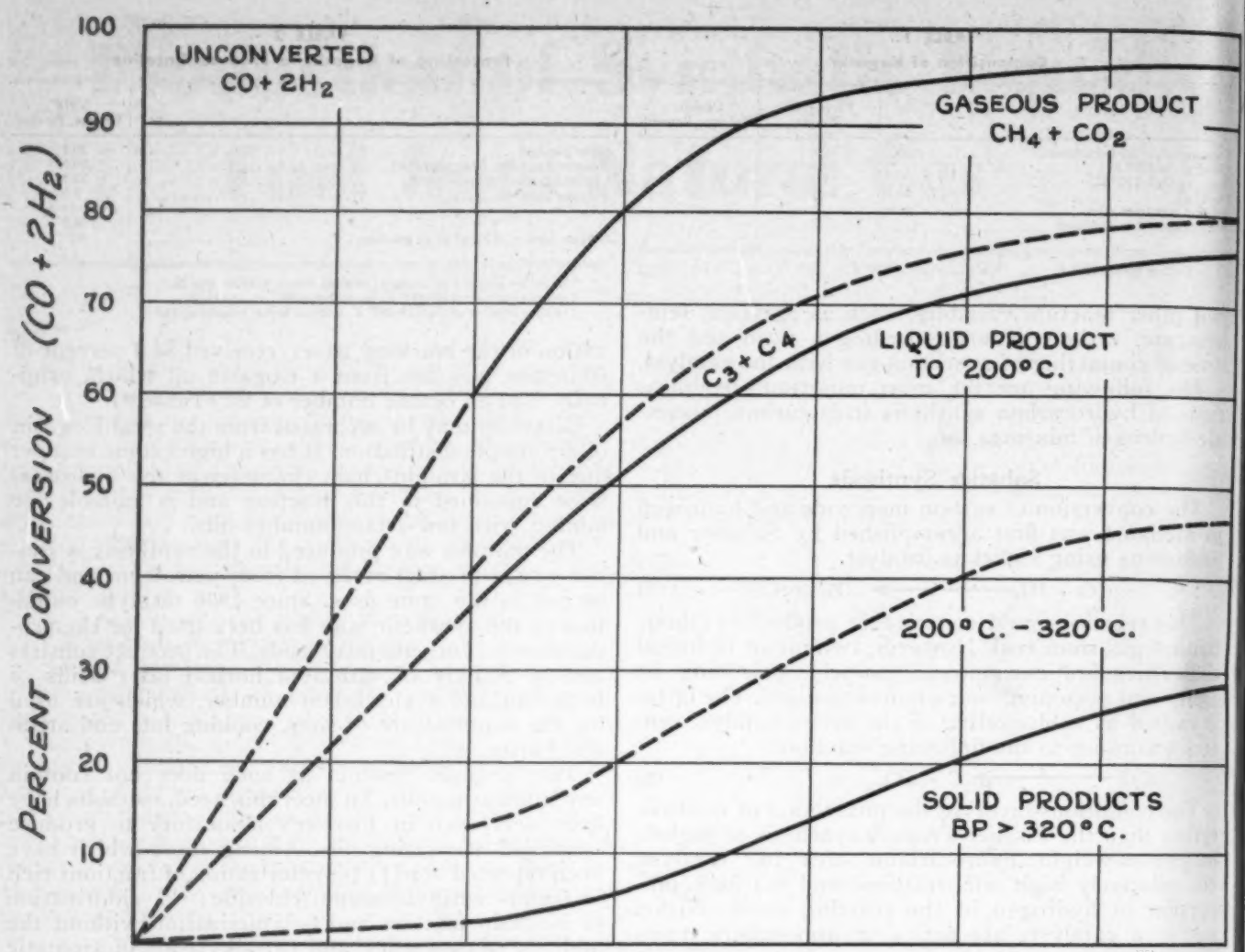


FIGURE 1
Effect of pressure on total yield and yield of various fractions.

rapidly due to formation of nickel carbonyl at these pressures.

In 1938 the synthesis of high-melting wax on ruthenium catalysts at high pressures was reported. In a study of certain metals of Group VIII of the periodic table (Ru, Rh, Pd, Os, Ir, Pt), ruthenium was found to produce solid hydrocarbons more effectively than any other metal of this group. Thus, at 1500 psi pressure and 383°F., 5.9 pounds of paraffin wax and 3.0 pounds of oil were obtained per 1000 cubic feet of gas ($2H_2$:1CO) with a ruthenium catalyst. No appreciable change in the activity of the catalyst occurred in a 6-months test. By solvent extraction of a solid paraffin obtained at 1500 psi pressure, a paraffin wax was obtained which had a melting point of 270-273°F. and a molecular weight of 23,000.

It can be generally noted that the increase of pressure affects the formation of higher-boiling hydrocarbons. (See Figure 1).

Since the start of World War II, two new syntheses have been announced, "naphthene synthesis" and 'iso-synthesis." The details have not been disclosed. Both of these discoveries are due to the direction of the reaction towards the production of a specific class of hydrocarbons, e.g. in the naphthene synthesis, naphthenes and aromatics are produced. As noted above, only saturated and unsaturated straight-chain hydrocarbons are synthesized in the Kogasin synthesis. In the production of aviation gasoline, this is a serious objection because of the low octane number of the product. However, by means of the "iso-synthesis," it is implied that iso-paraffins are produced directly and that the gasoline fractions would have high octane numbers. The C_4-fraction from the process contains 90 percent of iso-butane. This, in itself, is important, since by converting half of the iso-butane to iso-butene (by dehydrogenation) and alkylation of the remaining iso-butane with the iso-butene produced, 100-octane aviation gasoline could be produced.

Future Developments

Future developments of the Fischer-Tropsch synthesis must proceed in the following directions:

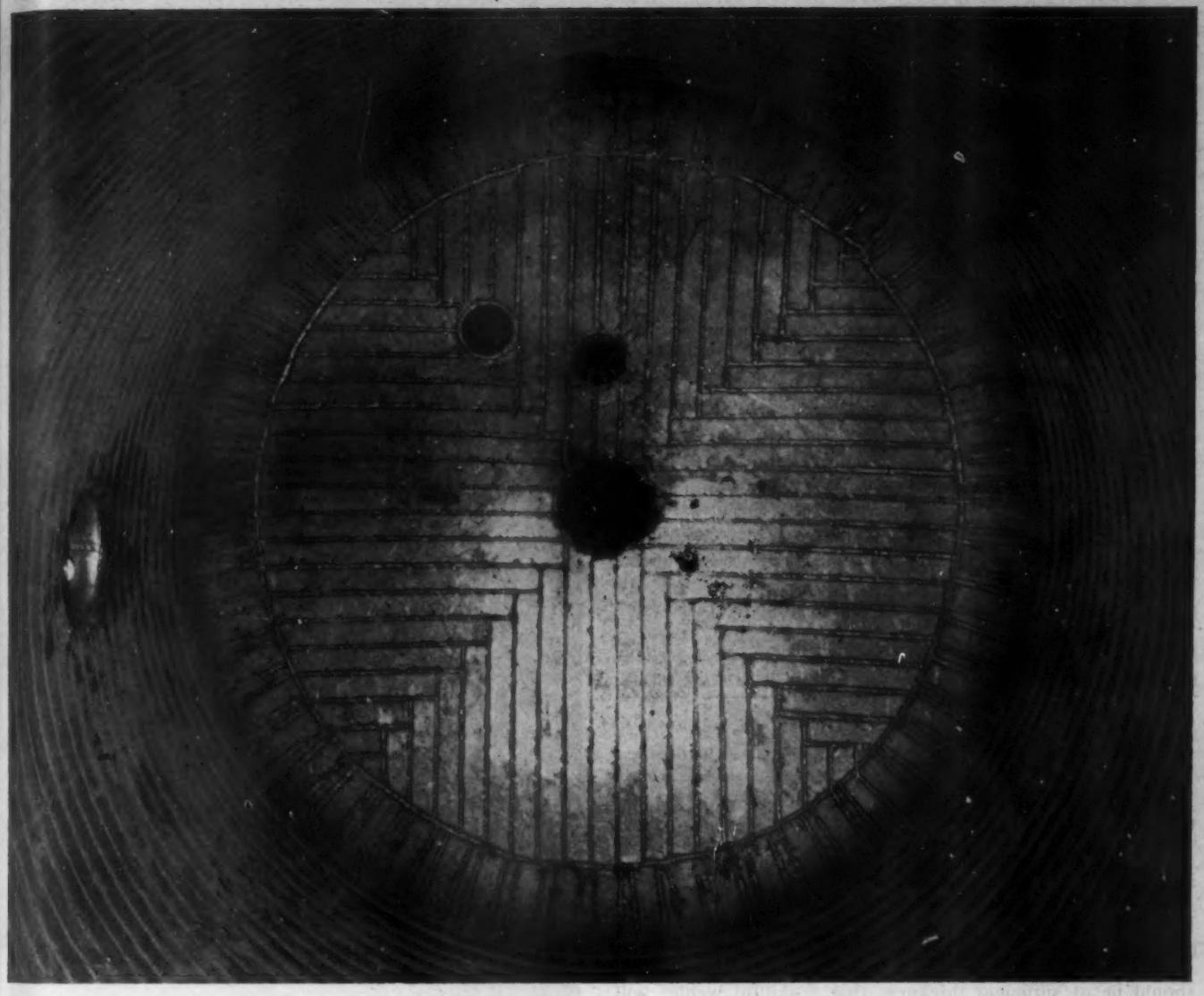
a. The development of a sulfur-resisting catalyst

b. The utilization of carbon monoxide-hydrogen mixtures of various composition

c. The synthesis of branched-chain hydrocarbons.

The last goal probably can be achieved by developing a "complex-action" catalyst combining the hydrogenating, polymerizing and isomerizing ability.

For more detailed discussion of the subject, see articles by Komarewsky and Riesz. Petroleum Refiner, November 1944 and National Petroleum News, Technical Section, February 7, 1944.



PROCEDURE FOR

Application of Stainless-Steel Strip Liners to Refinery Vessels in the Field

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SEVERAL methods used for field applying of stainless-steel liners to refinery vessels to give protection against high-temperature corrosive conditions were described in detail in the author's article "Field Lining of Refinery Vessels With Stainless Steel Sheets or Strip," REFINER AND NATURAL GASOLINE MANUFACTURER, *February, 1940*. In the past several years it has become generally recognized that the most economical of these methods is use of narrow steel strips, which are welded around their edges to the vessel wall. The author believes it is desirable to have a detailed description covering at least one satisfactory procedure for attaching these strip liners in order that the procedure may be described in detail when requesting bids or awarding contracts for application of such liners. The detailed procedure might also prove useful as a rough guide for the maintenance departments when applying the stainless liners themselves.

The following suggested procedure is based on an endeavor to obtain as fool-proof a job as possible. It attempts to circumvent to a maximum degree the danger always present of using welders of unproven ability and integrity. It is believed that if this procedure is carefully followed, a satisfactory liner job will result. At least "botching" or slighting of the work should be quickly and readily seen so that with a minimum of policing, a good job will result.

It should make it difficult to get a job that looks satisfactory that will not stand up in service.

Procedure

1. The stainless steel strips are to be of Type 410, 11½-13 percent chrome, 0.08 percent carbon maximum, No. 1 Finish, slit or sheared edge, sheet or strip with maximum hardness of Rockwell B-85. The material shall contain no aluminum.

The detailed analysis described has been found over long periods to be satisfactory for high-temperature service. The carbon should be held as low as commercially possible in order to minimize the air hardening on welding. The chromium should be a minimum of 11½ percent to assure ample corrosion resistance. It should be a maximum of 13 percent to guard against embrittlement after prolonged service. With material extremely low in carbon, an aluminum content is not believed necessary. The presence of aluminum (a very decided ferrite former) is considered to enhance the danger of embrittlement after prolonged service. Therefore, since it is not required and because there may be a distinct disadvantage in having it present, the author strongly believes that it should be restricted.

The maximum hardness is specified in order to assure ease in fitting—this is particularly desirable in the case of liners for manways, nozzles, and small-diameter towers; also where the surface to be lined is uneven due to having been subject to corrosion.

2. The width of the strip used shall be no wider than:

Maximum Operating Temperature of Vessel	Width of Strip, Inches
950° F. to 1000° F.	3
850° F. to 950° F.	3½
750° F. to 850° F.	4
Up to 750° F.	4½

These widths are suggested for typical cracking bubble-tower service. Where the on-stream time is relatively short or the temperature gradients are great due to coming on stream quickly or rapidly quenching when coming off stream, it is suggested that the widths be decreased.

3. Thickness of the stainless steel shall be .078-inch (the refinery may prefer to specify thicknesses of .109 or .093-inch).

The author prefers .078-inch thick material. The material should be of sufficient thickness that a skillful welder will have no great difficulty in welding the edge to the tower wall. On the other hand it should be as thin as possible so that it can be "fitted up" with the minimum effort. Because they believe that more economy can be obtained by the use of slightly thicker material for greater ease in welding, or because they prefer a thicker material to resist unusual mechanical abuse in service, some refinery engineers prefer .093- or .109-inch thick stainless steel strips.

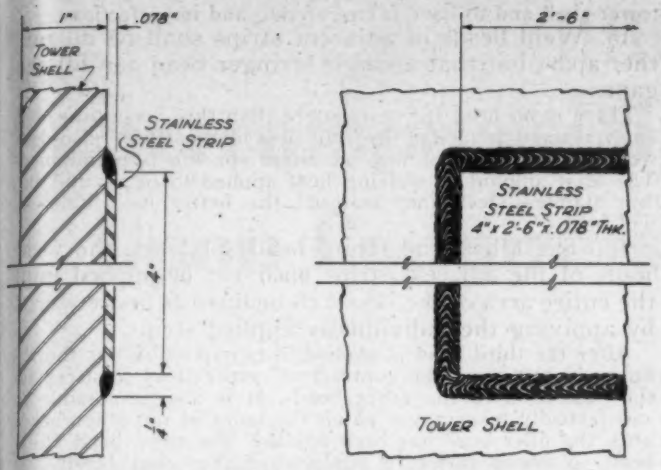
4. The lengths of the strips shall be no longer than 30 inches.

Thirty inches is suggested as the maximum length since it is believed that the short lengths are easier and quicker to apply. In addition, these short lengths make for more cross welds, which are desirable. They also allow the liner to be fitted more accurately. The short pieces can be handled and welded by one man, thus making it unnecessary to have a helper for every welder. This is particularly desirable in small towers where frequently the helpers would be more of a hindrance than a help to the welder.

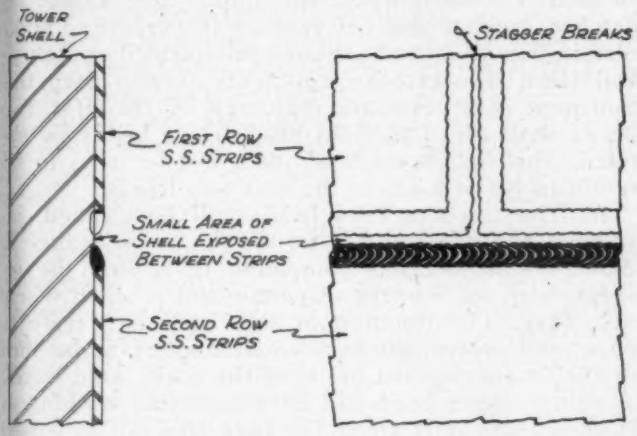
5. The weld rod shall be of Type 310, 25 percent chrome, 20 percent nickel stainless steel of an approved manufacturer. It shall be coated for arc welding and shall be ⅛-inch diameter. The contractor shall demonstrate that the weld rod he proposes to use will make satisfactory welds, under conditions existing on the job.

A weld rod to be satisfactory for stainless steel liner applications must be suitable for use in all positions. Before approving the use of any brand of weld rod, the refinery engineer should have it demonstrated to him to prove that the rod can be used in the horizontal, overhead, downhand, and vertical *coming down* positions for attaching the thin stainless steel strips to heavy steel plate. On the tests for demonstration, it is suggested that care be taken to assure that the rod is used with the low "heats" and short arcs desirable for

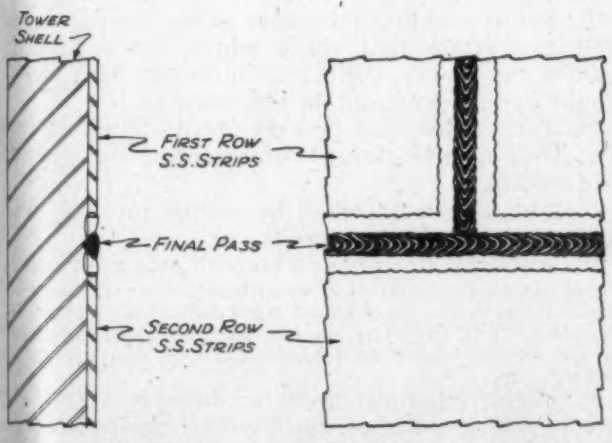
Section of lined vessel head showing welding of individual sections.



FIRST STEP. The first strip is applied horizontally and welded to tower wall completely around all the edges. The weld bead then is deslagged, inspected, patched and the patches deslagged. The weld bead firmly fastens the stainless strip to the tower wall and seals it off completely.



SECOND STEP. After completion of all steps in welding the first strip, as above, the second strip is applied. It is so spaced from the previously applied strip that weld beads of the second strip fasten the stainless steel direct to the tower shell; that is the weld bead of the second strip should not lap over into the weld bead of the previously applied strip. The weld beads of the second strip are deslagged, inspected and patched as in the case of the previous strip.



FINAL STEP. After all the strips have been individually welded to the shell as in the steps above, the weld beads are sandblasted, the sand brushed or blown off, inspected by the refinery inspector, patched where necessary, patches deslagged and again inspected. Then, and only then, is the third or final weld bead to be applied. The third weld covers the bare tower wall exposed between the previously applied beads. This bead is deslagged and patched by the welder as applied and finally inspected by the refinery inspector.

the application of these liners. It is believed that generally the vertical coming down is the most difficult weld to make, since there is a tendency with all stainless-steel weld rods for the slag to run ahead of the welding, thereby preventing the welder from seeing his work. There is a decided difference between various brands of stainless weld rod in this respect.

Use of Type 310, 25 percent chrome 20 percent nickel stainless steel weld rod is desirable in order that the weld bead resulting from the metal laid down from the weld rod, after being diluted both with the carbon steel from the vessel and the 11½-13 percent chrome from the stainless steel strip (penetration causes dilution of the weld bead) will still be sufficiently high in alloy to give ample corrosion resistance, and to assure a strong, tough and ductile austenitic structure.

6. The welding machines shall be in good mechanical and electrical condition, and shall have a capacity of 150 amperes maximum. They shall be electric-motor-driven D. C. machines.

The small welding machines are very much to be preferred to the usual 300-ampere machines. When welding at the 75 to 90 amperes desirable with the thin stainless steel, very much better consistency in the current delivered can be obtained with the small machine.

7. Each welder to be used for applying stainless-steel liners, before starting to work on the vessel, shall pass a qualification test to assure that he is capable of satisfactorily welding the thin strips in all positions.

Not every welder, even though he may be a very good code welder, is capable of applying thin liners. When testing welders for qualification, they should be allowed to practice for about an hour, and then be watched while applying .078-inch—3 x 6-inch strip Type 410 stainless steel to the *vertical* surface of a freshly cleaned steel plate at least ⅜-inch thick. The practicing and testing should be done using machines in good condition and with the same weld rod as to be used on the job. It is suggested that while watching the test particular attention be paid to the vertical coming down welds and the overhead welds. If it appears that the welder has not mastered the technique, he can be allowed to continue his practice for another hour, and then retested. On retest if he does not qualify he is best dispensed with at once. It is far better economy to use only welders who can do the job well than to attempt to use poor welders in the hope that good welders can be used to patch up the poor work. A good welder can start from scratch and line a given area quicker than he can patch up a poor welder's work on the same area.

8. Welding shall be done with currents no greater than 90 amperes for the ⅛-inch diameter weld rods. The arc length should be no longer than ⅛-inch.

Minimum possible heats are always desirable when welding stainless steel. When 25-20 weld rod is used, this is particularly the case. The cast structure of weld deposits of 25-20 is very apt to be "hot short"; that is, lacking in ductility immediately below the temperature at which it solidifies. Because of this it is desirable to have the weld bead cool as quickly as possible so that the chances of subjecting it to high stress in its hot short range will be minimized. One method of checking if the low "heats" are being used is the heating of the rod during welding. If very high heats are used and the rod burnt continuously, the ⅛-inch rod will become red hot and unusable while 4 to 6 inches of the rod are still unburnt.

A very short arc goes with the low heat. In addition, the short arc makes for better control of the welding and guards against the metal being oxidized, and loss of alloy elements while going through the arc.

9. Strips shall be applied with the long axis horizontal.

Horizontal are to be preferred to vertical strips on a contract job. Vertical beads commonly are made down hill, since it is considered that up-hill welding would be too costly both in labor and in weld rod. When the major welding consists of these long vertical beads, the refinery can never be certain that these welds have "full beads" and have been applied with sufficient "low heat." In order to keep ahead of the flux, when running the vertical beads, the welder is under a great temptation to turn up the "heat" on his machine so that he can move very rapidly. As mentioned above, weld beads of stainless, particularly 25-20, should always be made with the smallest "heats" possible. On the other hand, the major beads on the horizontally-applied strips hardly can be

made to look good without being at least reasonably certain that they have full "body" and are well tied into the tower.

10. Each edge of each stainless-steel strip shall be completely welded as applied; that is, a number of strips shall **not** be "fitted up" by tack welding and the main welding left for later. The strips shall not be lapped or shingled. Each strip shall be seal welded *along all edges* before the next adjacent strip is applied.

It is believed that far better workmanship can be obtained by individual welding of strips rather than by the "fit-up" method. There is less likelihood of a "leaker" affecting more than one strip. It is easier to assure perfection in the weld beads (lack of slag holes) because other strips are not in the way. There is much more certainty that each weld bead is tied into the vessel wall throughout its length. By gauging from the weld bead already laid, it is far easier to obtain the correct spacing between strips.

It is very important that 100 percent of each edge of all strips be firmly fastened to the shell of the vessel in order to obtain maximum strength. Narrow strips are used mainly because it is necessary to tie the stainless to the steel shell at frequent intervals in order to resist the stresses encountered in service. Strips should not be lapped or shingled. In addition to firmly fastening the edges individually to the vessel wall, the strips should be sealed off individually so that if in service a "leaker" develops, only one strip will be affected.

11. Weld beads of each strip shall be made, cleaned of slag, inspected (this inspection by the welder making the bead), patched where necessary and the patches cleaned before the next adjacent strip is applied.

It is far easier to clean and inspect and patch a weld bead if these operations are performed before the adjacent strip is in the way. Using this procedure there is very much less chance for adjacent weld beads to have "leakers" at exactly the same place. The welder will have to patch the major part at least of his own poor work—this is much better for morale than to force a welder to patch another welder's "sorry" work. This procedure also allows the welder to know definitely the quality of work he is performing. He will, therefore, materially improve as he goes along. Using this scheme of doing the major part of the patching as the work progresses, there are far less holes for the refinery inspector to catch when he inspects. He therefore has a better chance of catching all imperfections. Both the contractor and the refinery supervisor have a better chance of determining quickly and accurately just what kind of work each welder is doing. It is then possible to try to straighten out the poor welders by working with them. If there are welders on the job of such poor quality that they "can not make the job," they can be run off before they get a chance to botch a great deal of work.

It is easier to lay down the weld beads of subsequent strips when the previous beads are cleaned and patched. It is also easier to get desired spacing between strips.

12. After the first strip has been completely welded, the next strip shall be applied, so spaced that the weld beads of this next strip shall be thoroughly bonded to the vessel wall throughout their length. The weld beads must not be tied into the adjacent strips nor into the weld beads of the adjacent strips.

See note under No. 10 above. By specifying that each bead be tied into the vessel wall rather than to a previously laid bead, the refinery inspector can, at all times, during the progress of the work, check the quality of the weld beads; that is the weld beads are all visible. On the other hand if one weld bead is covered by another, the inspector has no way of determining the perfection of the underlying weld bead which is the important one since it ties the liner to the shell.

If a refiner is using his own welders in whom he has the proper confidence, he may elect to butt adjacent strips against the weld beads of previously applied strips. In this case the weld bead of the second strip would be tied into the weld bead of the first strip rather than into the tower. If this is done, the welders should definitely understand that they are not to lap or shingle the strips. They must weld the second strip either to the vessel wall or to a previously applied weld bead which is tied directly to the vessel wall—they must not weld a strip to a strip. The welders should also understand that if they use this "two-bead" method rather than the "three-bead" method, it is all the more important to have the first weld bead perfectly tied to the tower shell and to have it free of slag and imperfections.

13. Weld beads of adjacent strips shall be no further apart but that a single stringer bead can fill the gaps.

There is no need for more space than this. Less time will be consumed in doing the job (less down time) also less weld rod and labor if this minimum spacing is maintained. The least amount of welding heat applied to or around the thin stainless-steel liner material the better its toughness will be.

14. The filler bead (third bead) between the weld beads of the adjacent strips *must not* be applied until the entire area of the vessel to be lined is first covered by applying the individually applied strips.

After the third bead is applied, it is impossible for the refinery inspector or the contractors' supervisors to ascertain the perfection of the other beads. It is also impossible to satisfactorily inspect and patch the holes in the other beads after the filler bead has been applied. The third bead (filler bead) is much easier to apply after the other beads and patches have been cleaned by sand blasting.

15. After completing the job with strips individually welded on all edges of the vessel wall, the weld beads shall be sandblasted, inspected (this inspection by refinery inspector), thoroughly patched, patches cleaned (re-sandblasted if there are numerous patches), reinspected (by refinery inspector) to make certain that all holes have been satisfactorily patched; and then, if necessary, repatched. Only after this thorough inspection and patching of the first two beads shall the final weld bead (third bead) be applied. This final weld bead must not be used to attempt to patch holes in the first two beads.

16. The third or final bead shall be cleaned, inspected and patched by the welder as he makes it. After the welder has completed it, it shall be inspected by the refinery inspector and patched where necessary. The function of this bead is merely to cover and protect the very small amount of the shell of the vessel exposed between the other weld beads. A thin stringer bead will be satisfactory as long as it does completely cover the bare steel of the vessel walls.

17. Each welder shall have a steel stencil for identification and shall use this stencil to clearly mark all his work.

18. Every time arc is broken, welder shall clean the bead at the crater and a little back from the crater before striking the arc. Welding shall be picked up at least ½-inch back from where arc was broken.

19. Before welding the edges of the strips, welder shall be certain that these edges are snugly up against the tower shell and sufficient tack welds should be used to maintain this snug fit.

20. Tack welds shall be very small—about ¼-inch long. They shall be cleaned before proceeding with the main welding.

21. The tack welds shall be melted into the weld beads as the welding proceeds.

22. All welds must have a smooth neat appearance.

It is not claimed that nice, smooth welds are always good welds. However, a good sound weld will always appear to be "good." You definitely do not want to have welders on the job who lay down weld beads that look like popcorn on a string.

23. Weld rods must be burnt down to a stub end no longer than 2 inches. Each welder must return his own stub ends of weld rod before being issued additional rod.

This would principally concern the refiner on contract jobs, only where the refinery furnished the weld rod. Skillful welders can "burn" the 25-20 rod to this length with no difficulty. As mentioned before the length of the stub end is helpful in controlling the amount of "heat" used in welding. Long stub ends invariably mean that the "heat" of the machine is far too great for quality welds.

EFFECT OF
Supercompressibility of Natural Gas Upon Compressor Performance ☆

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THE factors relating to the compression of gases consisting principally of methane at normal pressures have been well established and we have been able to predict the performance of compressors operating under these conditions with good accuracy. When pressures and temperatures are such that deviations from ideal gas laws exist, the effect is known as supercompressibility, and the operation of the compressor cylinder under such conditions must be thoroughly understood in order to predict the volume throughput and horsepower involved.

The effect of supercompressibility is very pronounced at high pressures and even with so-called "dry" gases it may be worth recognizing at suction pressures as low as 200 pounds. With "wet" gas mixtures and those which are not principally methane, the effect usually is appreciable at low pressures. This discussion will be confined to performance at high pressures, though the methods presented are applicable to performance at any pressure if the factors are available. When we find a cylinder handling, in some cases, a throughput of 150 to 200 percent of that calculated neglecting supercompressibility, with a horsepower requirement in the same order of magnitude, we have a condition which we cannot afford to overlook. There seems to be some tendency to ignore the effect of supercompressibility upon compressor performance and to assume that discrepancies from this source can be neglected. It is the aim of this paper to point out the dangers of such a practice, to indicate the practical value of the proper treatment, and to present the methods of calculation which recognize this effect. Because this phenomenon

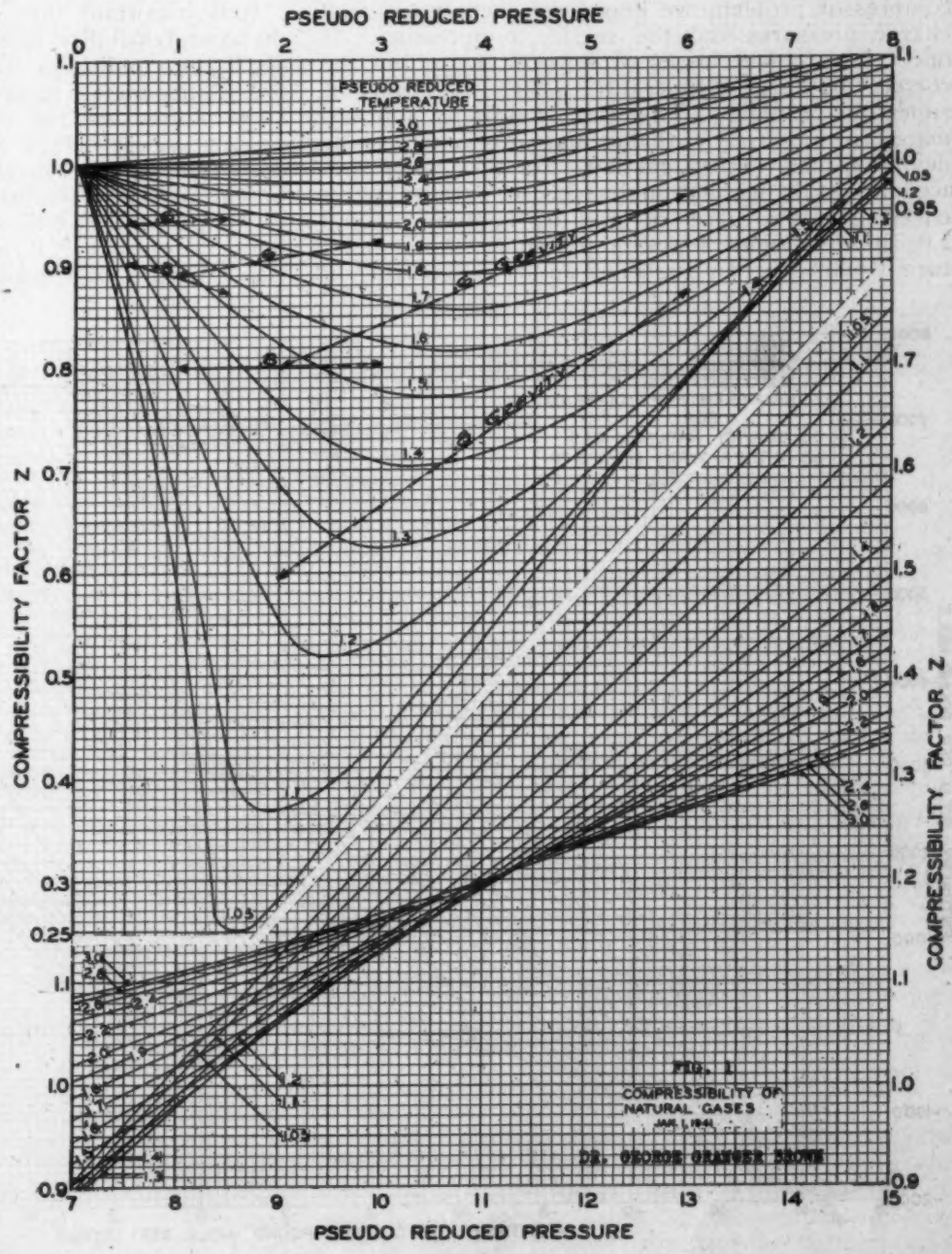

FIGURE 1

☆ Presented at the March 1, 1945, monthly meeting of California Natural Gasoline Association.

is usually most pronounced at relatively high pressures, a discussion of it is very timely as repressuring and cycling operations come to the fore.

Compressibility Factors

Excellent papers and curves on the subject of deviation of natural gas from ideal gas laws have been presented in recent years and are readily available.[1, 2] The methods of calculating compressibility factors have been adequately treated and need no review here, except, perhaps, to emphasize that the factor is a multiplier used in finding the volume occupied by a given weight of "deviated" gas from the volume occupied by the same weight of gas under ideal gas laws. Curves have been published showing compressibility, or "Z" factors for natural gases as a function of the pseudo-reduced pressures and temperatures. In Figure 1 we reproduce those of Dr. G. G. Brown.[1]

For the gas being compressed it will be necessary to determine these compressibility factors at both suction and discharge conditions. Normally for any compressor problem we know the suction and discharge pressures and the suction temperature. At once the problem arises of how to determine the correct discharge temperature under conditions of supercompressibility. This can readily be approximated from entropy-enthalpy diagrams in which the deviation from perfect gas laws has been taken into account. Dr. Brown[3] has published a set of these curves covering natural gases of gravities between 0.6 and 1.0, through wide ranges of pressure and temperature. By his courtesy Figures 2 and 3, for gravities of 0.6 and 0.7 are reproduced. From a point corresponding to the pressure and temperature at suction conditions follow a vertical line of constant entropy to a point showing the discharge pressure. The temperature may be read directly. This is adiabatic compression, of course. If the analysis of the gas is available, the exact pseudo-critical temperature and pressure (required for use in determining the compressibility factor from Figure 1) can be determined by methods shown elsewhere.[1] If only the gas gravity is known, these pseudo-critical constants can be closely approxmiated by curves which have been prepared for this purpose by the Gas Measurement Committee of the California Natural Gasoline Association and they are presented in Figure 4. The pseudo-reduced pressure, P_r is equal to the absolute pressure in pounds divided by the pseudo-critical pressure, P_c. The pseudo-reduced temperature T_r is equal to the absolute temperature in degrees Rankine divided by the pseudo-critical temperature, T_c. With this information and Figure 1 we can readily determine the compressibility factors for both suction and discharge conditions.

It is important that we get the relation between the compressibility factors at suction and those at discharge conditions. To make this clear, the compressibility factors at several suction conditions have been plotted on the compressibility factor curve, Figure 1, and each of these has been connected by dotted lines to the corresponding compressibility factors at discharge conditions. As an illustration, ratios of compression of 3 have been chosen, and an intake temperature of 60° F. has ben selected in all cases. Gas gravities of 0.6 and 0.8 have been shown. In

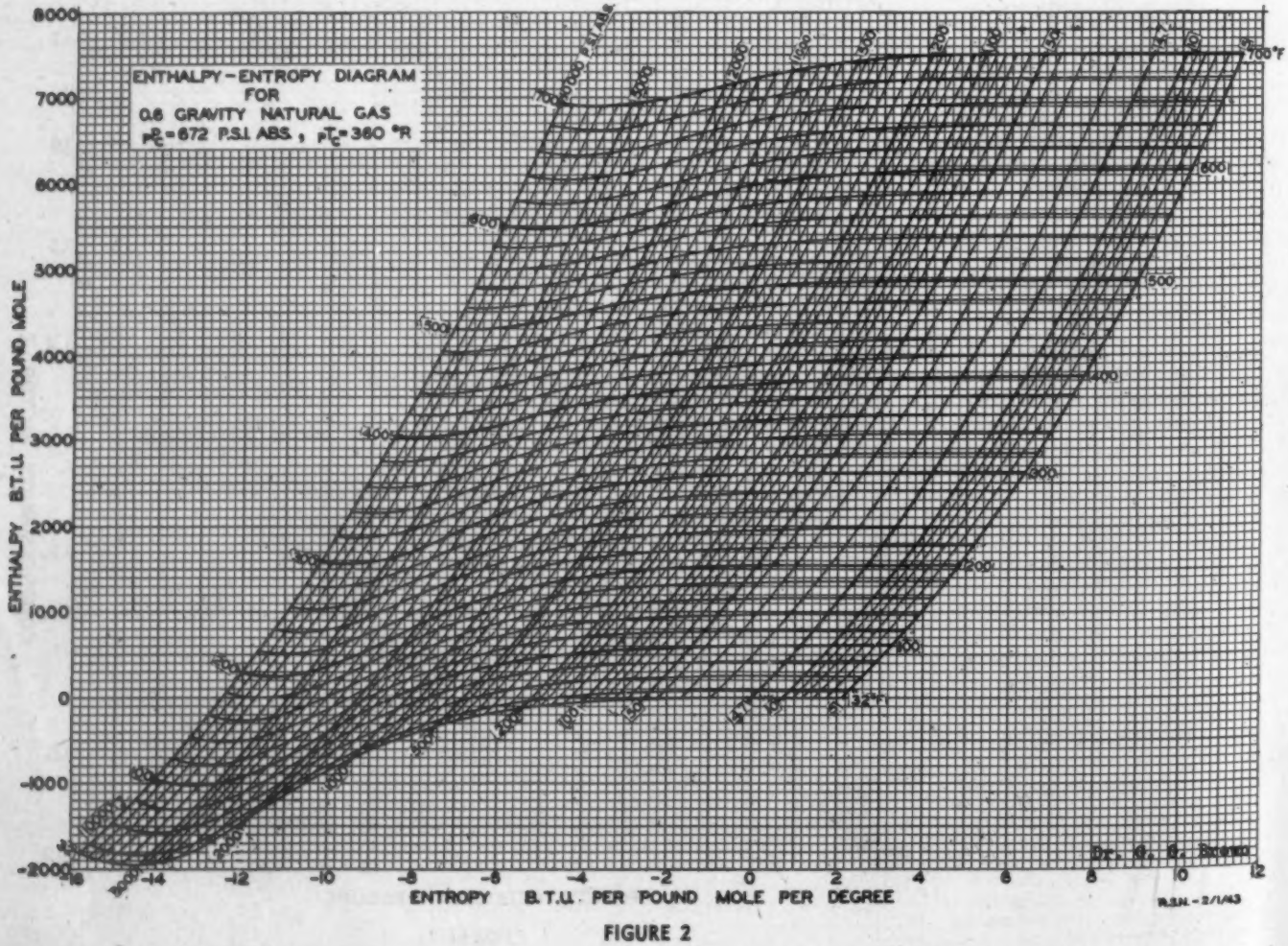
ENTHALPY - ENTROPY DIAGRAM
FOR
0.6 GRAVITY NATURAL GAS
P_c = 672 P.S.I. ABS. , T_c = 360 °R
ENTHALPY B.T.U. PER POUND MOLE
ENTROPY B.T.U. PER POUND MOLE PER DEGREE
Dr. G. G. Brown
R.S.N. - 2/1/43

FIGURE 2

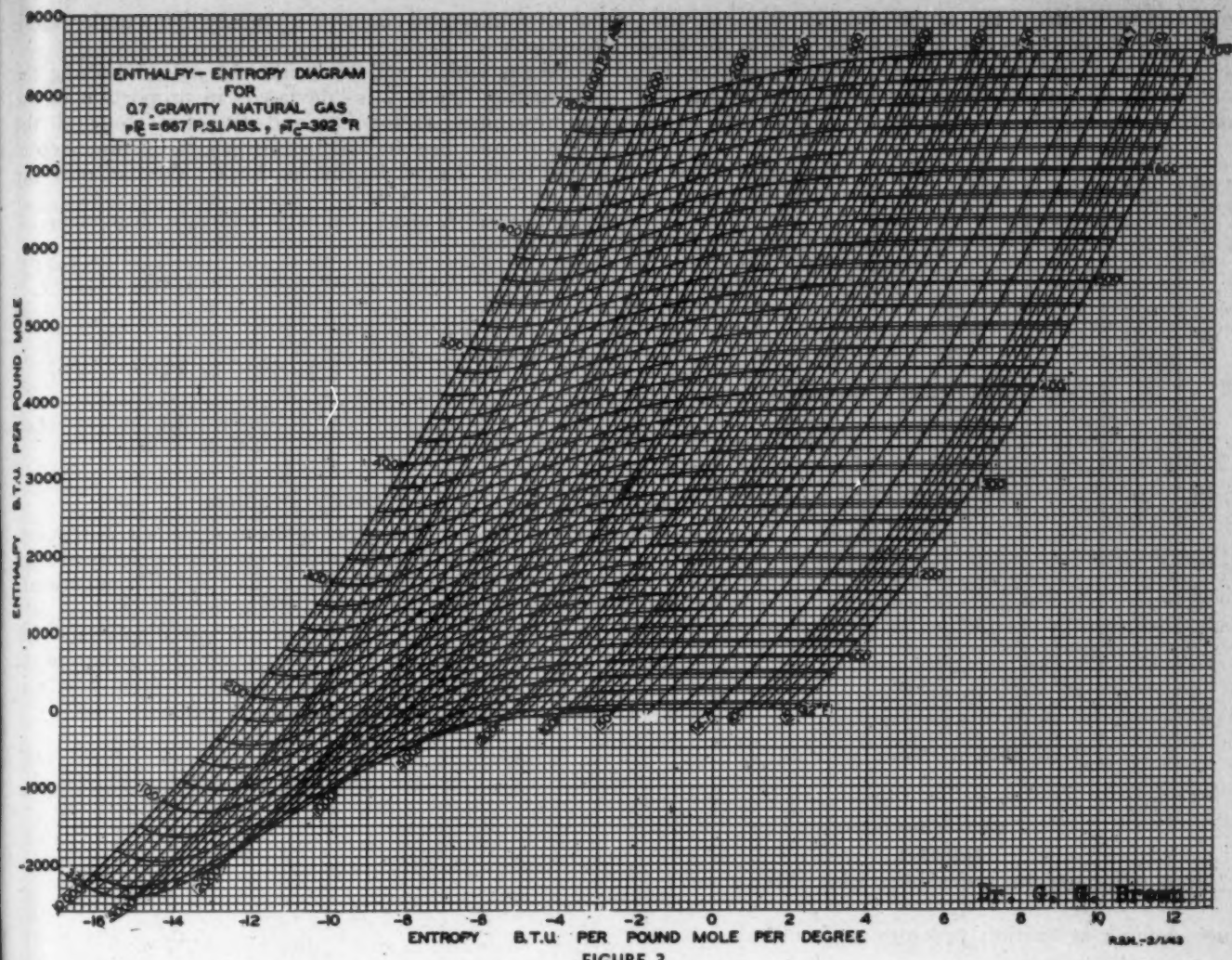

FIGURE 3

general it may be seen that the compressibility factors are lower at suction conditions than they are at the corresponding discharge conditions, except where the suction pressures on heavier gases are below the pseudo-critical pressure. In the few cases where the compressibility factor at suction is higher, there is not much difference between the factors.

It is interesting to note that the increase in temperature due to compression always tends to raise the compressibility factor at discharge, hence, in the left hand area of the curve, this effect tends to compensate for the drooping curves and equalize the factor at suction to that at discharge conditions. In the right hand area where the curves are rising, the effect is cumulative, and wide differences between factors at suction and discharge occur, with the greatest deviation from ideal gas laws occurring at suction conditions. This characteristic is important as it relates itself to the performance of compressor cylinders at high pressures.

Cylinder Capacity

Without doubt, the clearest method of showing the effect of supercompressibility upon the capacity of the cylinder is the conventional indicator PV diagram, Figure 5. The end of the discharge stroke, 4, is a point fixed only by the construction of the cylinder and is the proper starting point for such an analysis. The clearance volume, 4, a, represents that which is in the cylinder head at the end of stroke of the piston. Under ideal gas laws the gas within this volume would reexpand to point 1 according to the accepted volumetric efficiency formula

$$E_v = K - C\,(\overline{R^n} - 1) \qquad (1)$$

where the value for K is theoretically 1.0, but is frequently assumed to lie between .95 and 1.0 to allow for ring and valve leakages; C is the clearance in percent, R is the ratio of compressions, and n is the exponent for the reexpansion. If the length of stroke 8, 2 is chosen as unity, then the length of the suction line 1, 2 is also the volumetric efficiency.

If the gas within the cylinder at discharge conditions has deviated from ideal gas laws and the compressibility factor is less than 1.0, the clearance volume 4, a, contains a greater weight of gas, or more standard cubic feet than would be contained in this volume under ideal gas laws. If this volume is reexpanded down to suction conditions, and if no deviation from the gas laws occurs at this point, then the volume occupied by the clearance gas becomes $\frac{(b, 1)}{Z_d}$ or b, 5. The volumetric efficiency in such a case is represented by 5, 2.

Under *most* conditions as has been shown previously, when there is a deviation at discharge conditions, the deviation is still greater at suction conditions. In any event, whenever deviation exists at all under suction conditions the volume occupied by the reexpanded clearance gas must be reduced from b, 5 by the compressibility factor at suction, Z_s, which moves point 5 to

point 6. (In Figure 5 the compressibility factor at suction was smaller than that at discharge.) Thus we may say that the volumetric efficiency under conditions involving supercompressibility can be designated by E_{vs} and is determined by correcting the "expanded" clear-

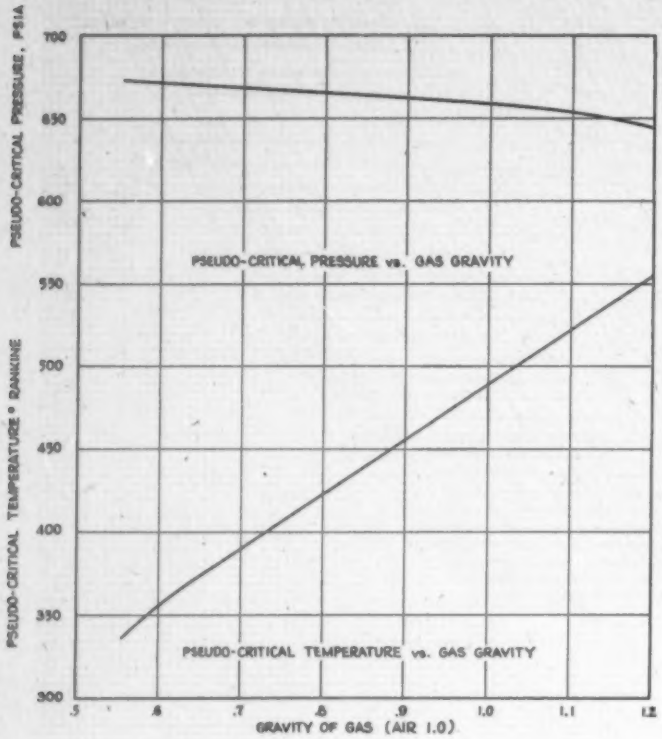

FIGURE 4

Pseudo-critical properties of hydrocarbon gases. (C.N.G.A. data.)

ance volume at suction pressure under ideal gas law conditions by the ratio $\frac{Z_s}{Z_d}$. This can be written as follows:

$$1 + C - E_{vs} = (1 + C - E_v)\frac{Z_s}{Z_d}$$

$$E_{vs} = 1 + C - (1 + C - E_v)\frac{Z_s}{Z_d} \qquad (2)$$

where C = percent cylinder clearance.

Or we can make the proper correction to the volumetric efficiency formula

1. Expanding the formula,

$$E_v = k + C - CR^{\frac{1}{n}}$$

The $CR^{\frac{1}{n}}$ term applies to the gas which is reexpanded, therefore this term must be corrected by $\frac{Z_s}{Z_d}$ to permit the formula to apply under conditions of supercompressibility. Under such conditions

$$E_{vs} = k + C - CR^{\frac{1}{n}}\frac{Z_s}{Z_d}$$

$$= k - C(R^{\frac{1}{n}}\frac{Z_s}{Z_d} - 1) \qquad (3)$$

It is obvious at this point that if the compressibility factor at suction is equal to the compressibility factor at discharge, even though they do not equal 1, the *shape* of the card is not changed, and $E_v = E_{vz}$.

Thus we have a method of finding the volumetric efficiency under conditions involving gases which deviate from ideal gas laws. This is essential for the next step, that of finding the *capacity* of the cylinder under these conditions.

The gas which was taken into the cylinder along the new suction line 6, 2 is "deviated" in proportion to the compressibility factor Z_s, and therefore to find the actual volume in standard feet of gas, the volume represented by 6, 2 must be divided by Z_s. We can now say that

Cylinder capacity under conditions involving supercompressibility

$$= \text{Capacity calculated neglecting supercompress.} \times \frac{E_{vs}}{E_v \times Z_s} \qquad (4)$$

$$= \text{Cylinder Displacement} \times \frac{E_{vs} \times \text{Suct PSIA} \times 520°}{Z_s \times 14.7 \times (460 + t° \text{ suct})} \qquad (5)$$

This formula can be used in either form except when $E_v = O$. Formula 5 must be used in this case.

Capacity Problem

In order to clarify the application of the foregoing, let us solve a problem involving cylinder capacity at high pressure. A gas of 0.65 gravity and 80° F. temperature is to be compressed from 1500 psia to 4500 psia in a cylinder of 15 percent clearance whose displacement is 45,000 cubic feet per day. It is required to compare the capacity of the cylinder when deviation from ideal gas laws is neglected and when it is recognized:

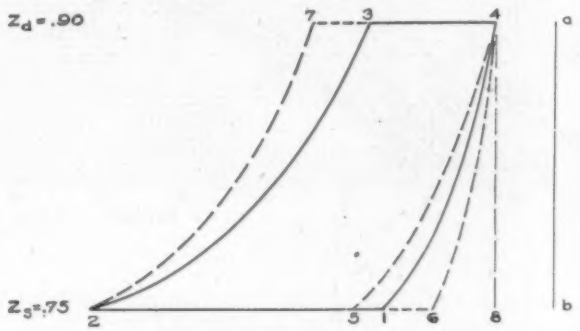

FIGURE 5

Neglecting deviation, $E_v = K - C(R^{\frac{1}{n}} - 1)$

assuming the reexpansion "n" = 1.2

K = .97

R = 4500/1500 = 3.0

then $E_v = .97 - .15(3^{\frac{1}{1.2}} - 1) = .745$

Capacity in Std. Cu. Ft./day = Disp. in C.F./day $\times E_v \times \frac{\text{Suct. psia}}{14.7} \times \frac{520}{T° \text{ Suct.}}$

$$= 45{,}000 \times .745 \times \frac{1500}{14.7} \times \frac{520}{540}$$

$$= 3{,}290{,}000$$

For the computations when deviation is recognized: The compressibility factor at suction conditions is determined thus,

Pseudo-critical Pressure, $P_c = 670$ psia (from Fig. 4)

Pseudo-reduced Pressure, $P_r = \frac{P}{P_c} = \frac{1500}{670} = 2.24$

Pseudo-critical Temperature, $T_c = 373°R$ (from Fig. 4)

Pseudo-reduced Temperature, $T_r = \frac{T}{T_c} = \frac{540}{373} = 1.45$

Compressibility factor at suction, $Z_s = .78$ (from Fig. 1)

Similarly, the compressibility factor for discharge conditions can be calculated:

From Figure 2, rising vertically from the suction

condition of 1500 psia and 80° F., to 4500 psia, the discharge temperature is seen to be 230° F. for a gas of 0.6 gravity. Similarly, from Figure 3, the discharge temperature is seen to be 220° F. for a gas of 0.7 gravity. For the required condition of 0.65 gravity, an average temperature of 225° may be assumed.

$$\text{Pseudo-reduced Pressure, } P_r = \frac{P}{P_c} = \frac{4500}{670} = 6.72$$

$$\text{Pseudo-reduced Temperature } T_r = \frac{T}{T_c} = \frac{685}{373} = 1.84$$

$$Z_d = .98 \quad \text{(from Fig. 1)}$$

$$E_{vs} = 1 + C - (1 + C - E_v) \times \frac{Z_s}{Z_d} \qquad (2)$$

$$= 1.15 - (1.15 - .745) \times \frac{.78}{.98}$$

$$= .828$$

$$\text{Capacity} = \text{Capacity neglecting deviation} \times \frac{E_{vs}}{E_v \times Z_s} \qquad (4)$$

$$= 3{,}290{,}000 \times \frac{.828}{.745 \times .78}$$

$$= 4{,}690{,}000 \text{ Standard Cubic feet per day.}$$

Thus, due to supercompressibility, the capacity of this cylinder under these conditions has been shown to be greater by $\frac{4.69 - 3.29}{3.29} = 42.5\%$

Effect of Clearance

Formulas 4 and 5 being related to volumetric efficiency indicate that the correction factors obtained therefrom vary with the percent of cylinder clearance. The reason for this is apparent from the diagrams of Figure 6. If the clearance volume 4, a is small, then the volume b,

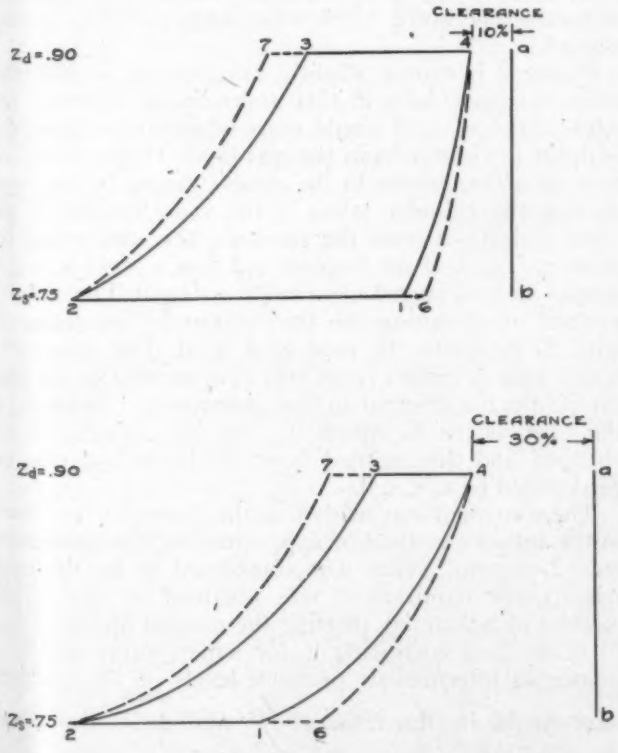

FIGURE 6

1 is small, and so is the $\frac{Z_s}{Z_d}$ correction to it, 6, 1. When the clearance 4, a is large, b, 1 is also large and the $\frac{Z_s}{Z_d}$ correction to it makes 1, 6 much larger and a greater proportion to the uncorrected E_v, 1, 2. Thus, where Z_s is not equal to Z_d it becomes apparent that the greater the clearance, the greater is the effect of deviation upon calculated cylinder capacity. Normally we *increase* the cylinder clearance whenever we desire to

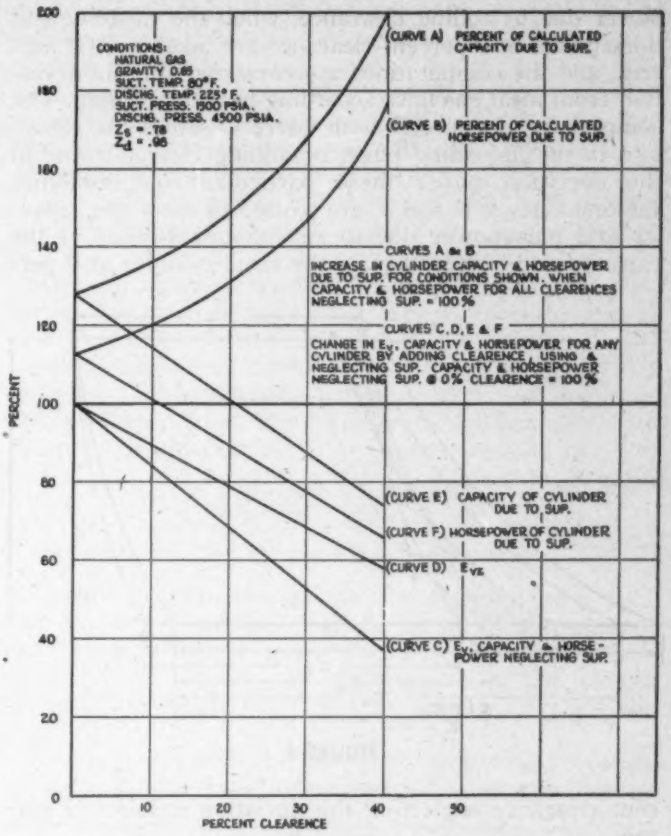
CONDITIONS:
NATURAL GAS
GRAVITY 0.65
SUCT. TEMP. 80° F.
DISCHG. TEMP. 225° F.
SUCT. PRESS. 1500 PSIA.
DISCHG. PRESS. 4500 PSIA.
Z_s = .78
Z_d = .98
(CURVE A) PERCENT OF CALCULATED CAPACITY DUE TO SUP.
(CURVE B) PERCENT OF CALCULATED HORSEPOWER DUE TO SUP.
CURVES A & B
INCREASE IN CYLINDER CAPACITY & HORSEPOWER DUE TO SUP. FOR CONDITIONS SHOWN. WHEN CAPACITY & HORSEPOWER FOR ALL CLEARENCES NEGLECTING SUP. = 100%
CURVES C, D, E & F
CHANGE IN E_v, CAPACITY & HORSEPOWER FOR ANY CYLINDER BY ADDING CLEARENCE, USING & NEGLECTING SUP. CAPACITY & HORSEPOWER NEGLECTING SUP. @ 0% CLEARENCE = 100%
(CURVE E) CAPACITY OF CYLINDER DUE TO SUP.
(CURVE F) HORSEPOWER OF CYLINDER DUE TO SUP.
(CURVE D) E_{vs}
(CURVE C) E_v, CAPACITY & HORSEPOWER NEGLECTING SUP.
PERCENT
PERCENT CLEARENCE
0
20
40
60
80
100
120
140
160
180
200
10
20
30
40
50

FIGURE 7

Effect of supercompressibility upon compressor cylinder operations for conditions shown.

decrease the cylinder capacity. In the usual case, where Z_s is smaller, this unloading effect is reduced by the deviation from ideal gas laws. Indeed, one is entitled to wonder if increasing the clearance might not increase the cylinder capacity instead of decreasing it. Such is not the case, though the unloading effect due to adding clearance can be greatly offset by the application of formula 2.

The curve of Figure 7 is shown to illustrate this effect. As in the foregoing example, gas of 0.65 gravity and 80° F. temperature is being compressed from 1500 psia to 4500 psia. The compressibility factors at suction and discharge are noted. In curve A, cylinder clearances up to 40 percent are plotted against the percent increase in cylinder capacity due to supercompressibility. This curve shows that for a clearance of 40 percent the cylinder can be expected to handle 201 percent of the volume calculated neglecting the deviation. At 0 percent clearance there is obviously no volumetric efficiency correction. The increase of capacity to 128 percent at this point is merely $\frac{1}{Z_s}$ or $\frac{1}{.78}$. Although horsepower has not been discussed as yet, it is plotted as curve B to make the group complete and to correspond with curve A. It is obtained merely by multiplying the percent increase in capacity as shown in curve A by 61.6/70, which is the ratio of horsepower per million standard cubic feet per day when recognizing supercompressibility to the horsepower factor neglecting it. Curve C shows the de-

crease in cylinder capacity and horsepower with increase of clearance when no deviation occurs, using the capacity at 0 percent clearance as 100 percent. This curve merely constitutes a plot of the normal volumetric efficiency versus clearance relationship. Similarly, curve D plots E_{vz} and shows the decrease in capacity and horsepower due to adding clearance, when the capacity and horsepower at 0 percent clearance are taken as 100 percent, and the computations are corrected for the deviation from ideal gas laws according to the foregoing. The comparison of curve D with curve C shows the reduction in the unloading effect of adding clearance due to the deviation under these particular compressibility factors. Curves E and F are plotted to show the capacity and horsepower due to supercompressibility if the capacity and horsepower of the same cylinder at 0 percent clearance neglecting the deviation equals 100 percent.

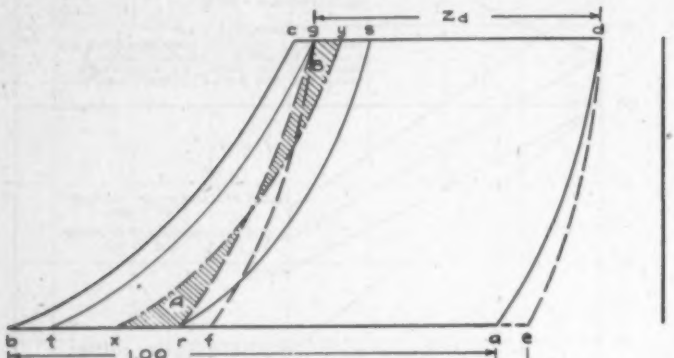

FIGURE 8

Horsepower Requirement

The effect of supercompressibility upon the horsepower of the cylinder is clearly shown on the indicator diagram. In a manner similar to that by which we corrected the reexpansion line, we can also correct the compression line. On Figure 6 where Z_d is greater than Z_s (greater deviation from ideal gas laws at suction conditions) it is apparent that as the gas is being compressed, the deviation thereof will be reduced, and it will occupy a *greater* volume than it would have done had the deviation remained unchanged. By applying the ratio of compressibility factors at various pressure increments to those at intake conditions and correcting for the slight temperature differences, the true compression line can be plotted. This is shown on Figure 6 as 2, 7. It is obvious what happens to the horsepower requirement of a cylinder handling gas under the conditions shown. It is increased both on the compression and reexpansion ends of the cylinder. And, of course, the cylinder with the largest clearance provides the greatest percentage increase.

A great deal of confusion has centered around this point. Under most conditions of supercompressibility the horsepower required to compress a given weight of gas will be less than for ideal gas law conditions. For any particular compressor cylinder, however, if the deviation of the gas being compressed is greater at suction, that cylinder will handle an excess of gas great enough to more than offset the reduced horsepower per pound, and for this reason the horsepower required by the cylinder will be increased beyond the requirement for gases which do not deviate from ideal gas laws. From the indicator diagram it will be apparent that the only condition for which the size of the card (and therefore the horsepower of the cylinder) will be unchanged under conditions where the gas deviates from ideal gas laws will be that where the compressibility factor is the same at discharge as it is at suction conditions. In such a case the cylinder will handle an increased weight of gas as compared to ideal gas law conditions, due to Z_s in the denominator of formula 4. Because the horsepower for this cylinder is unchanged, then obviously the horsepower per pound is reduced. Usually, however, Z_s is less than Z_d and therefore we can generalize by saying that under most conditions of supercompressibility, the "horsepower per million" is decreased, but the horsepower per cylinder is increased. It is obvious that we must not confuse the two cases.

Horsepower by Approximate Method

Since from the foregoing we can determine the *capacity* of any cylinder when handling gas which deviates from ideal gas laws, we have only to know how to obtain the horsepower per pound, or per million standard feet of gas under such conditions in order to determine the horsepower required for the cylinder. Several methods have been developed to provide it. The author has developed a very rapid approximate method which, in the solution of a number of problems covering a wide range of conditions, has given a maximum error of 2 percent. This method of determining the horsepower requirement consists of averaging the compressibility factor at suction with that at discharge and taking the average as the percent by which the horsepower per million neglecting supercompressibility is multiplied to find the corresponding horsepower per million cubic feet per day, measured at 14.7 psia and suction temperature when supercompressibility is considered.

Figure 8 is shown, slightly exaggerated, to illustrate what has been done in this approximate method. The solid card a, b, c, d would exist when compressing gas without deviation from the gas laws. If the stroke on a single-acting piston in the same cylinder is shortened so that the cylinder takes in the same weight of gas when it deviates from the gas laws, the card would become e, f, g, d. If we displace e, f to a, r, card a, r, g, d defines an area almost identical to e, f, g, d. The author's method of obtaining the horsepower by averaging Z_s with Z_d produces the card a, x, y, d. The amount by which area A differs from area B in percent of the total card is the major error in this assumption. Obviously, in the case where Z_s equals Z_d, the "n" values are not changed and this method is exact. In such a case the card would be a, r, s, d.

The statement was made that the greatest error found in the author's method of approximating the horsepower was 2 percent. What was considered to be the exact horsepower requirement was obtained by the tedious method of accurately plotting the normal indicator card to scale, then correcting it for supercompressibility at numerous intermediate pressure levels on the compression stroke by the ratio of $\frac{Z_p}{Z_s}$ and $\frac{T°_{zp}}{T°_p}$. For the reexpansion line correction, the clearance gas was corrected by the ratio $\frac{Z_p}{Z_d}$ for several pressures. The areas of the normal and the supercompressibility cards were then accurately measured. After correcting for the increased weight of gas in the cylinder when it had deviated from ideal gas laws, the horsepower per unit

weight of gas was obtained for both cases. The ratio of the two was then obtained. This ratio was then applied to the accepted brake horsepower charts to provide the exact BHP/MMCF for compression involving supercompressibility. This laborious method was only used to check the accuracy of the several methods of making horsepower determinations.

Horsepower by Average "n"

Edmister[4] has suggested that the horsepower required for hydrocarbons which deviate from ideal gas laws might be closely approximated if we knew the "n" value of the compression line both at the beginning and the end of compression, and used the average of the two in the theoretical horsepower formula

$$HP = \frac{144\ P_1\ V_1}{33{,}000}\left(\frac{n}{n-1}\right)\left[R^{\frac{n-1}{n}} - 1\right]$$

This article dealt with hydrocarbons at relatively low pressures, and the $\frac{C_n}{C_v}$ ratio table presented therein would not cover the range of high pressures which are the subject of this discussion. However, the method gives a fair approximation for the horsepower in the high pressure area, provided we realize that the horsepower formula above is based upon perfect gas laws, and that the V_1 term must be corrected by the compressibility factor at suction. In this formula it will be recalled that to determine the horsepower per million standard feet per day it is customary to substitute $\frac{1{,}000{,}000}{1{,}440}$ for V_1, and 14.7 for P_1, regardless of what the actual initial pressure and volume might be. Such a procedure is predicated upon the assumption that Boyle's law holds, and that the term $P_1\ V_1 = k$. When Boyle's law does not hold, the product of $P_1\ V_1$ will likely be much smaller at suction conditions than at atmospheric pressure. Hence, to make it correct for the proper suction pressure we must multiply $P_1\ V_1$ at atmospheric pressure by Z_s. In our concept of horsepower[5] we should recall the definition for work, which is the product of force times distance. If the gas deviates from Boyle's law, and the volume of gas to be compressed occupies a space smaller than Boyle's law would indicate, then the distance through which the force (piston) must act is reduced, and the work, and thus the horsepower per pound, is lessened.

The method of determining the horsepower by use of the average "n" is tedious but not difficult. The slope at the extreme ends of the compression line after making the supercompressibility and temperature corrections is determined by the familiar graphical solution, well described by Gill.[6] The average provides the "n" value needed. When someone provides us with $\frac{C_p}{C_v}$ ratios ("n" values) which will exist at suction and discharge conditions at the pressures being considered, this method of calculating the horsepower requirement will be greatly simplified. Differences up to 9 percent between this "average n" and the "exact" methods previously described, have been noted when used in the high pressure range. Values so determined are nearly always low.

Horsepower from Mollier Diagrams

A simple method of finding the horsepower per pound or per million standard feet per day has been worked out for us by Dr. G. G. Brown in the Entropy-Enthalpy or Mollier diagrams for natural gases,[3] shown in Figures 2 and 3. These diagrams have been developed from the chart of Figure 1 and recognize the deviations from ideal gas laws. The enthalpy, or total heat in Btu can be read at a point corresponding to suction conditions, and by assuming that the work of compression follows the adiabatic path of constant entropy, a vertical rise to discharge conditions will indicate the Btu enthalpy at this level. The difference, expressed in Btu, is the work done in raising one pound mole of the gas from suction to discharge conditions. This can readily be converted to horsepower per million standard cubic feet per day from the knowledge that one pound mole of gas occupies 379 cubic feet at 14.7 psia and 60° F. if $Z = 1.0$. And at standard conditions of pressure and temperature, any "deviation" is negligible and Z can be assumed to be 1.0.

Thus, for any of the Mollier diagrams, the Btu difference shown for compressing the gas from one condition to another is the Btu required to compress 379 standard cubic feet through this range. Knowing that 1 Btu = 778 foot-pounds we can determine the conversion factor from Btu to theoretical horsepower per million standard feet per day by the expression.

$$\text{Theor. HP/MMSCF/day} = \frac{\Delta\ \text{Btu} \times 1{,}000{,}000 \times 778}{379 \times 24 \times 60 \times 33{,}000}$$

$$= \Delta\ \text{Btu} \times .0432$$

It must be remembered that the Mollier charts provide Btu per pound-mole, and therefore the horsepower determined therefrom will be the horsepower per million *standard* feet per day, when the gas is at the suction temperature which was used in reading the Mollier chart.

By application of the proper factors, this theoretical horsepower can be converted to brake horsepower. The factors involved are the compression efficiency, which represents principally the compressor valve losses, and the mechanical efficiency of the compressor. These losses vary with the design of equipment, speed, ratio of compression, etc. A comparison of the theoretical horsepower required per million cubic feet per day at 14.7 psia and suction temperature

$$\text{Horsepower} = 44.6 \times \frac{n}{n-1}\left(R\,\frac{n-1}{n} - 1\right) \qquad (7)$$

and the charts showing brake horsepower per million for hydrocarbons as published by Worthington[8]

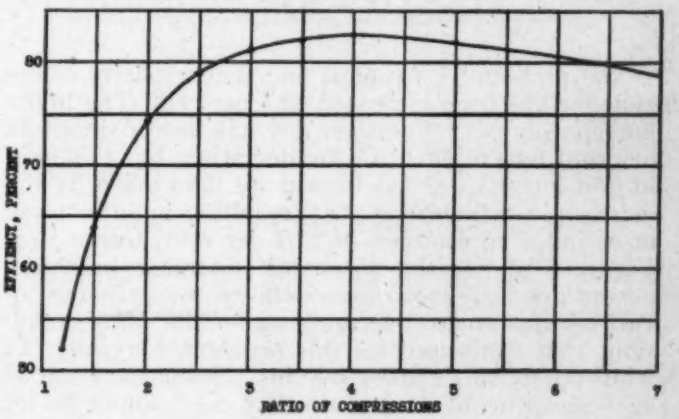

FIGURE 9

Ratio of $\frac{\text{Theoretical Horsepower}}{\text{Brake Horsepower}}$ for modern angle compressor
(Combined compression and mechanical efficiencies)

indicate that these combined efficiencies vary with ratio of compression as shown on Figure 9. These efficiencies can be used for the determination of brake horsepower from the theoretical horsepower obtained from the Mollier charts.

Horsepower Problem

When applied to the same problem which was used to demonstrate the capacity calculations, we can determine the horsepower requirements by the author's method as follows: Averaging the compressibility factors,

$$\frac{Z_s + Z_d}{2} = \frac{.78 + .98}{2} = .88$$

(The "exact" method as described above gave a factor 1.6% lower than this.)

BHP/MMSCF/day neglecting supercompressibility = 70.0 (from BHP charts).

BHP/MMSCF/day recognizing supercompressibility = 70 × .88 = 61.6. The decrease due to supercompressibility is 12 per cent.

The capacity of the cylinder was previously shown to be increased to 4,690,000 standard cubic feet per day under conditions of supercompressibility, therefore

$$\text{BHP for the cylinder} = 4.69 \times 61.6 = 289$$

If supercompressibility were neglected, the load on this cylinder would be calculated to be 3.290 x 70.0= 230 BHP.

The load increase due to the deviation from ideal gas laws is obviously

$$\frac{289 - 230}{230} = 25.6\%$$

The problem is a typical one. The capacity of the cylinder has been increased 42.5 per cent. The brake horsepower per million per day has been reduced 12 per cent by the effect of the deviation, but this gain in unit horsepower has been more than offset by the increase in cylinder capacity, resulting in an increase in cylinder horsepower of 25.6 per cent. Curve B of Figure 7 shows the percentage increase in horsepower due to supercompressibility for cylinders of various clearances, operating under the same conditions that were used for this problem. Certainly the wide differences caused by this phenomenon are of such an order of magnitude that they cannot be ignored. The conditions of gravity, temperature and compression ratio are probably quite similar to those found in cycling plants, hence the curves shown could be typical of actual field conditions.

One is entitled to ask, at this point, that if supercompressibility is sometimes ignored when computing compressor cylinder sizes or determining capacity and horsepower, why more trouble has not been encountered on such jobs? In the first place, it is problematical as to whether or not this practice of neglecting supercompressibility is really "widespread." High pressure installations are increasing, but their number is still relatively small, and what trouble has been caused from this source is rather hard to learn. If an operator handles more gas than he expects, he does not usually regard it as trouble. If his high-pressure cylinder is greatly overloaded, it is usually only one of several cylinders on a single compressor, and the other cylinders often work on other services so that the overload is only on one cylinder out of the group. If a gas and load excess occurs on a unit carrying only high-pressure cylinders, removal of a valve or addition of extra clearance usually remedies the situation so easily that it is not considered a problem. The modern gas-engine-driven compressor is so "over-powered" that it will take large overloads without much disturbance. Frequently the gas in a repressuring or cycling plant is two-staged, with cylinders of both stages on each compressor. In such cases the low-pressure cylinder is usually not greatly affected by supercompressibility. The high-pressure cylinder probably is. But the volume handled by each compressor unit is fixed by the capacity of the low-pressure cylinder, therefore the excess capacity of the high-pressure cylinder due to gas law deviation only serves to lower the intermediate pressure, and therefore no appreciable increase in capacity for the unit is obtained. Because the intermediate pressure is reduced, the load is reduced on both the low and the high pressure cylinders.

Even though the discrepancies described above may not, in some cases, be too hard to rectify, there is little excuse for us to make them. With the methods so easy to use we should size the cylinders to handle the correct throughput and be able to predict the correct horsepower requirement when gases deviate from ideal gas laws.

Above all, we should not fail to take advantage of the marked reduction in the horsepower requirement for compression due to supercompressibility. In the high-pressure regions, reduction of 15 per cent are common. Cycling plants frequently process huge volumes to high pressures and require large compressor installations. A reduction of 15 per cent in horsepower in such cases represents no small saving in money. In a recent cycling-plant installation, taking advantage of the reduction in horsepower due to supercompressibility meant elimination of one compressor unit which, including installation costs, represented a saving that ran into six figures.

The methods which have been presented above will permit computations for compressor-cylinder capacity and horsepower under conditions of supercompressibility to be made with good accuracy. They are simple and easy to use. It is hoped that the illustrations regarding the magnitude of the errors involved by neglecting the deviation from ideal gas laws in regions where it should be considered, and the savings which may be made by recognizing this effect, have been sufficiently convincing to encourage common use of these methods.

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[8] "Plain Talks on Air and Gas Compression" Vol. IV, Worthington Pump & Mach'y Corp.

SYNTHESIS OF Molecules With Lubricant Properties

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MODERN theories of lubrication defining the mechanism of lubrication with viscous mineral oils and fats have specified certain conditions necessary for the molecular structure of the oil in order to obtain various desirable qualities, such as resistance to pressure, adhesion, etc.

These principles have explained certain empirical methods of procedure and have directed organic syntheses into new paths. Thus lubricant oiliness agents, sometimes assymetrical and polar character, improve lubricants even though they are used in small proportions.

It is evident that such research will contribute permanent results now and even more so when conditions are again normal.

This paper was presented before La Societe Chimique de France, November 13, 1942, and is here presented as translated by E. J. Barth, petroleum technologist.

THE coefficient of friction of two ideally polished surfaces, rubbing one against the other, is without practical value. There is a field of superficial force which opposes the relative shifting of the contacting surfaces and can even tend, in certain cases, to reweld them one to the other (Johannsen's Swedish gauge). It is necessary to reduce the coeffcient of friction, to relieve or diminish this field of superficial force, either by spreading a film of oil between the interposing surfaces, which is the "perfect" or hydrodynamic lubrication; or by modifying the surfaces themselves, as in covering them with an extremely thin film, solidly adsorbed, resulting in an appreciably weaker field. This is termed "imperfect," or oiliness lubrication. In the case of less polished surfaces the role of the lubricant is to form a more uniform surface by filling the pores and spreading a thin layer of oil across the high spots.

It is necessary to study the viscosity of molecular groups, the relation to their structure, and also the "oiliness" that must be determined; the latter is defined as the ease with which molecules become adsorbed on metallic surfaces forming thin molecular fields of force (mono-molecular films).

Perfect Lubrication

The rubbing surfaces containing the adsorbed film of oil are thus separated by oil, the properties of which can be calculated by means of the rules of laminar or plastic flow. The perfect system is established when the speed is not too low (so that the pressure can be equalized which originates in the moving fluid), or too high in order to avoid a whirling or "turbulent" condition. This latter cannot be characterized by a single parameter, the viscosity, and it involves a special summary of the forces of friction.

Reynolds has given the first mathematical theory of perfect lubrication which was later developed by Sommerfeld, Mitchell, etc. In particular, we find the following experimental facts:

1. The critical speed which separates the quiet state from a turbulent one is in proportion to the viscosity which appears as a constant factor in perfect lubrication. It is this also which avoids increasing breakdowns or local disturbances and which thus permits the coating to adhere more tenaciously.

2. Frictional resistance is proportional to viscosity, generally speaking. Choice of lubricant consists first, therefore, of choosing a viscosity neither too high (to avoid loss of energy), nor too low (to assure stability in the film of oil).

Viscosity and Chemical Constitution

A number of difficulties arise when one wishes to establish the relation of viscosity of liquids and their chemical constitution. Indeed it is not sufficient to compare viscosities at the same temperature; one must compare the relations of the viscosity-temperature curves.

In the majority of cases one can represent the viscosity-temperature curves by a relation of the formula $U \times W = C$. The Variables U and W being related to the variables V (viscosity) and T (absolute temperature) by the equation: $\log V - a = U$, and $Tb = W$; a and b, being constants for a given body.

The comparison of viscosity curves are obtained by first considering the values of C.[1]

We see in Table 1 that these values obviously correspond for the three chemical substances which are quite different, such as the saturated hydrocarbon, glycol, and anthracene hydrocarbon.

The chemical properties therefore have a somewhat limited influence on the viscosity.

This can be explained when one considers that only certain bond energies between activated molecules determine the chemical behavior of the latter,

TABLE 1

	C	A	B
Octane-n	463.5	3.850	211.8
Butane-diol	472.7	3.6340	162
Dihydro-dicoamylanthracene	449.5	2.8225	0

TABLE 2

	C
Glycol	433.2
Propane-diol	561.8
Butane-diol	472.7
Pentane-diol	795.1
Hexane-diol	693.5
Decane-diol	482.4

while it is probable that all the forces intervene in the viscosity of a liquid; on the other hand, certain properties such as the polarization of molecules influence chiefly in the value of C. Table 2 shows that the diols with uneven atoms show a greater value of the constant C than the diol preceding or the diol following.

Hugel notes in his interpretation of these facts that the tendency to alternate polarities of carbon atoms is different with the even carbon atoms of glycols while with glycols of odd carbon atoms the two terminating hydroxyl groups are susceptible to negative polarization.[1]

The result is a difference in basic behavior from the point of view of the association in liquids. One must realize that these studies are merely beginning and that it is in the field of practical experience that we must seek useful indications concerning the nature of lubricating molecules.

First experiments were carried out on oils solvent-extracted from petroleum. Certain oils such as the paraffinic Pennsylvania are produced in limited quantities and show an average elementary analysis indicating their formula to be approximately $C_n H_{2n-4}$, for n between 16 and 25; when n is over 25 we pass progressively from the formula $C_n H_{2n-8}$ to $C_n H_{2n-20}$ (Mecca oil). In the same way, the heavy oils of Texas show an average formula of the $C_n H_{2n-12}$ to $C_n H_{2n-20}$. These results indicate nothing concerning the aliphatic, cyclic, naphthenic, or aromatic nature of the oil.

Considerable work in methods of solvent extraction together with methods of chemical analysis have led to the following facts:

Aliphatic compounds have a low viscosity which but slowly diminishes with rise in temperature; their freezing point is quite high which makes these oils poor for lubrication of cars at low temperatures.

Mono- or polynuclear aromatic compounds have a high viscosity at low temperatures and diminish rapidly as temperatures rise. They are, therefore, mediocre lubricants in the cold, becoming plastic, and at high temperatures the viscosity becomes very low; bearing pressures then tend to rupture the film of oil. We shall note that these oils or compounds, despite their disadvantages, show valuable lubricant properties because of the remarkable resistance to pressure of the films which they form. We do not wish to discard such oils as lubricants but to retain at least some groups of these oils which show these desirable properties.

The compounds that are most interesting from a lubrication standpoint are the aliphatic compounds with branched chains and above all, the naphthenic compounds with many side chains, which can be quite long; the latter are prepared, starting with aromatic hydrocarbons and subjecting them to hydrogenation under pressure; this saturates certain cyclics and furnishes the route to obtain branched saturated chains.[2] Results are shown in Table 3 where viscosities and viscosity indices of various pure synthetic hydrocarbons are shown.

The viscosity index requires a special definition; the only reasonable method of defining a liquid from the point of view of its viscosity would be to give the coefficients a, b, c from formulas cited above or the coefficients of all other empirical formulas judiciously chosen.

In practice one frequently uses the viscosity index which is described as follows:

Let us suppose that the oil being considered has a viscosity of U (Saybolt sec. at 100° F.) and V (Saybolt sec. at 210° F.); say a Pennsylvania oil with a viscosity H at 100 and V at 210, and a Gulf Coast oil with a viscosity L at 100 and V at 210; the viscosity index is defined by the formula:

$$\text{V.I.} \quad \frac{\frac{L}{V} - \frac{U}{V}}{\frac{L}{V} - \frac{H}{V}} \times 100 \quad \frac{L-U}{L-H} \times 100$$

This index therefore is equal to 100 for Pennsylvania oils which are excellent as to their property of holding viscosity at high temperature; a value of 0 is obtained for Gulf Coast oils which is considered very poor, these oils thinning rapidly. However complex the definition may be the viscosity index is convenient to use. For purpose of argument let us tenta-

TABLE 3

	Type	Mol. Weight	Viscosity at 100° F. CST.	Viscosity Index	d_4^{20}
Dihydrodiethylanthracene	Polycyclic aromatic	236	35.7	−390	1.014
Dihydrodioctylenthracene	2 long side chains	404	293	−9	0.948
Phenylbenzylheptadecane	$C_6H_5—CH_2—CH(C_6H_5)—(CH_2)_{14}—CH_3$	406	34.5	+85	0.917
Dicyclohexylhexadecane	$(C_6H_{11})_2CH—(CH_2)_{14}—CH_3$	390	32.9	+98	0.879
n-butylthentriacontane	$CH_3(CH_2)_{14}—CH(CH_2)_3CH_3—(CH_2)_{14}—CH_3$	492	25.2	+151	0.824

tively say that an oil is as good as its index is high (it can be over 100) and as poor as its index is low (it can also be negative).

Synthesis of Viscous Compounds

In theory it does not matter what viscous medium is used as a lubricant. The viscosity is the only parameter which defines the film of oil under determined conditions. In fact it is necessary to take into account, besides the stability of the lubricant, its inertness to chemical agents, to heat, cold, and any corrosive action on surfaces which it is supposed to protect.

Therefore, in certain special cases of lubrication mixtures of glycerine (91 percent), water (7 percent) and sodium oleate (2 percent) are used. Such a liquid lowers the coefficient of friction of steel upon steel to the value of 0.1017.

Actually, one could also use, in other cases, sodium lactate, or the so-called "per-glycerine," etc., in concentrations of 80 percent solution; traces of oily compounds are also added as well as molasses, mucilage, etc. It has even been suggested that a concentrated lye solution can be used in certain extreme cases. (See Table 4).[3]

But except for these cases of viscous oils it is only to the synthetic hydrocarbons upon which we can rely that we look to supply our needs for lubricants. We shall see, however, that certain lubricants, either in colloidal form or in water emulsion, also give equally good service.

Synthesis of Hydrocarbon Lubricants

The problem is to synthesize hydrocarbons of high molecular weight, naphthenic as far as possible, with long straight or branched aliphatic side chains.

A study has been made of the relatively mild conditions of polymerization which give long straight chains without undue branching or forming short chains.

What are the possible sources of raw materials? Ethylene, a by-product of the cracking industry, polymerizes easily and has been thoroughly studied in this respect.[4, 5] But we also have equal access to the higher olefines, the lightest being furnished by cracking gases while the heavier are found in certain fractions (200°-300° C.) of synthetic hydrocarbons from the Fischer-Tropsch process (hydrogenation of carbon monoxide in the presence of various catalysts such as nickel and cobalt). These heavy fractions of the Fischer oil which is designated as "kogasine" are rich enough in higher olefines to be converted into excellent oils by polymerization.[6]

Methods of Synthesis

On the other hand, we have at our disposal paraffinic hydrocarbons with straight chains from the treatment of natural petroleum oils, artificial oils, as well as the aromatic compounds formed by the distillation of coal. In addition to the above, heavy paraffins can be cracked in vapor phase, giving lighter olefines.

The action of heat and pressure, electrical discharges and the use of various catalysts allow olefines to be converted (alone or with aromatic hydrocarbons) into heavy lubricant molecules; also saturated halogenated derivatives are easily condensed with aromatic compounds. One can also polymerize directly halogenated derivatives by cracking, which becomes a dehalogenating reaction.

TABLE 4

Viscosity of "Per-Glycerine." (Aqueous solution).

Temperature	RATE			
	50	60	70	80
100 degrees	1,020	1,123	1,386	2,492
80 degrees	1,079	1,277	1,728	3,790
60 degrees	1,231	1,594	2,800	13,910
40 degrees	1,733	2,510	7,720	74,600
20 degrees	2,630	8,010	43,780	959,780

Polymerization of Olefines

By the combined action of heat and pressure lubricants can be prepared by well defined procedure.[7] One operates at about 200 atmospheres at temperatures varying from 650°-750° C. The duration of the reaction denoted by T influences very much the nature of the product obtained; empirical formulas have been proposed to correlate it with standard temperature[8]:

$$\log T = Kt \times (750° - t.)$$

This method is not being used extensively.

Berthelot was the first to point out that saturated or unsaturated substances polymerize under the action of electrical discharges. It seems that radicals are formed, which re-group themselves into heavier molecules—from free radicals by loss of H+ ions. This procedure has been recommended by de Hamptinne for the preparation of lubricating oils.[9] The raw oils used in this treatment were mainly of vegetable or animal origin. This process is more general and allows oils called "Voltol-oils" to be obtained even from crude paraffins as well as vegetable fats.

"Voltol-oils," whose viscosity index and viscosity itself are very good, are used in mixtures in small amounts with the lower grades of mineral oils. These "Voltol-oils" show colloidal phenomena which we will discuss later. These oils are made under the following conditions: temperature 70° C.; current frequency of around 100; tension is several thousands of volts. One employs an atmosphere of nitrogen or hydrogen; thus we obtain oils with a high viscosity of 150 Engler at 100° C.

Catalytic polymerization of olefines is commonly carried out in the presence of sulphuric or phosphoric acid on silica gel; or better, by the use of various halides of aluminum, zinc, titanium, phosphorous, or boron (BF_3). For example, on contact with the aluminum chloride, ethylene under pressure is transformed at ordinary temperatures into an oil called "free oil" with the formation of an intermediate complex of mineral oil and hydrocarbon-metallic halide.[10, 11]

This latter, often called "combined oil," can be separated from the inorganic portion it contains by a steaming treatment; the proportion of this complex is almost constant during the course of polymerization. To modify the oils so obtained one can be guided by conditions of the reaction, nature of the catalyst, and by utilization of oil by-products:

1. A rise in temperature diminishes the life of the catalyst and increases the activation of the molecules which leads to lighter and diversified products;

2. The catalyst has been modified with success by Howes who used additions of aluminum or zinc powder when working under pressure at ordinary temperatures. Hall, Wiggins and Nash work at higher temperatures—around 250° C., in the presence of aluminum chloride (1/3 in weight) mixed equally with powdered aluminum. It probably forms a true organometallic aluminum compound which decom-

TABLE 5

Catalyst	Temperature C°	Viscosity at 100° F.	Viscosity Index
Aluminum chloride	15	112	—30
Aluminum chloride	150	200	—230
Aluminum chloride plus—Al powder	200	1610	67
Aluminum chloride plus Al powder	300	217	40
Boron Fluoride	Low	133	45

poses at 300° C. in light olefines. Table 5 gives a resume of the various results obtained.[12]

The real problem here is to moderate the action of the catalyst. Recently we have found that it is sufficient to add traces of water. In practice we add to the aluminum chloride the quantity of water which is theoretically sufficient to form aluminum hydroxide. We then obtain products which are more viscous and of a much lower bromine number. Finally, one should operate in two steps: first, slowly for a long time-period which secures long-chain material, then rapidly, to terminate the polymerization. Thus we begin the polmerization at 0°-30° C., then raising the temperature to 50°-80° C. for a very short period, if we desire viscous lubricants, or to 100°-120° C. if more fluid oils are wanted.

Finally, the work of Sullivan[13] and his collaborators, Thomas and Carmody[14] and others have shown that olefines with straight chains polymerize more quickly than ethylene itself to give lubricating oils in proportion to the chain length of the raw olefine. The cyclic (cyclopentene) olefines lead to lower grade oils, that is, low viscosity-index lubricants. The branched olefines will yield oils depending on the position of the double bond. The following figure shows the importance of the position of the double bond in olefine material as related to the viscosity index of the synthetic lubricant. Furthermore, a complex oily mixture such as "kogasine" also yields very satisfactory lubricants by polymerization. Synthetic oils made from that material are shown in Table 6 and indicate the percent of olefines in the raw stock (given in the second column).

Condensation of Olefines with Aromatics

The catalysts used are boron fluoride, aluminum chloride, as well as phosphoric acid or sulphuric acid. The oils obtained show pronounced aromatic character and have a low viscosity index. It would be necessary to use them in a mixture or hydrogenate them. The best process would consist in passing (under pressure) gaseous olefines through the mixture of aromatic compounds with the catalyst in suspension. This has not been practiced very extensively.

Chlorination of paraffins (proceeding slowly in the cold, and more rapidly at high temperatures with catalysts) leads to a mixture of halogenated derivatives, which may be catalytically or thermally treated. For instance, by the action of sulphuric acid,[15] preferably at 150° C. Aluminum chloride, etc., brings about the loss of the halogen as HCl; it produces at the same time a variety of condensations. A dichlorokogasine thus treated leads to an oil having a viscosity of 100 centistokes at 100° with medium viscosity index. This method has not been used to any great extent since the oils are somewhat unsaturated, and consequently not very stable. After hydrogenation, however, excellent oils would be obtained but are probably high priced.

Condensation of chlorinated derivatives with aromatic compounds reactions take place between mixtures of chlorinated compounds and aromatic hydrocarbons. One obtains very viscous oils of low viscosity index when using polychlorinated paraffins with short chains. On the other hand, chlorinated paraffins with long chains lead to the formation of viscous oils that hold up well under temperature changes. This method is very adaptable and leads to excellent products.

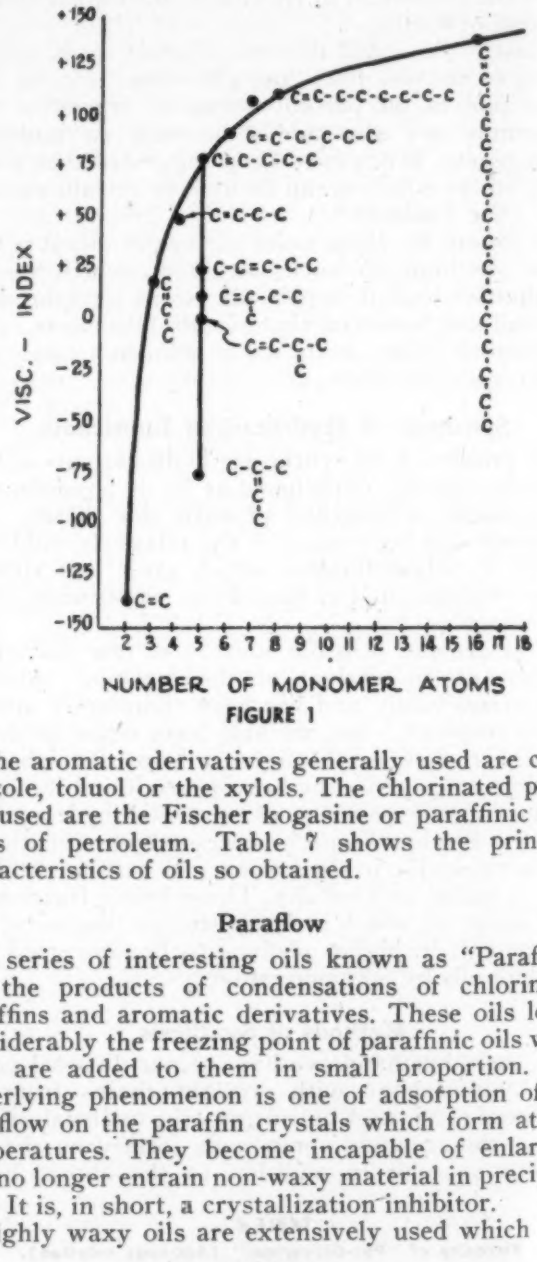


FIGURE 1

The aromatic derivatives generally used are crude benzole, toluol or the xylols. The chlorinated paraffins used are the Fischer kogasine or paraffinic fractions of petroleum. Table 7 shows the principal characteristics of oils so obtained.

Paraflow

A series of interesting oils known as "Paraflow" are the products of condensations of chlorinated paraffins and aromatic derivatives. These oils lower considerably the freezing point of paraffinic oils when they are added to them in small proportion. The underlying phenomenon is one of adsorption of the paraflow on the paraffin crystals which form at low temperatures. They become incapable of enlarging and no longer entrain non-waxy material in precipitation. It is, in short, a crystallization inhibitor.

Highly waxy oils are extensively used which con-

TABLE 6

Fraction Percent	Olefine Percent	POLYMERIZED OIL	
		Viscosity at 100° F. (CST.)	Viscosity Index
0—100	39	67	5
100—150	27	65	35
150—200	18	51	75
200—250	11	21	100

TABLE 7

Nature of the Chloro Compound Used	Viscosity at 100° F. (CST.)	Viscosity Index
Dichloro	65	10
Trichloro	140	—35
Tetrachloro	1,300	—100
Hexachloro	12,000	—300

tain additions of such synthetic materials in amounts of 0.1-1.5 percent. One can thus avoid dewaxing of paraffinic oils which is costly and which lowers the viscosity index, increases volatility, and lowers oxidation resistance.

Among the new substances proposed for the above purpose attention is called to compounds which are polymers obtained by condensation of aryl-alkyl ketones with halogenated derivatives of short chains. Or when using naphthenic acids that are first treated with phosphorous or sulphuryl chloride and finally polymerized with aluminum chloride;[16] these are some of the methods indicated for synthesizing heavy lubricant hydrocarbons.

Synthesis of Heavy Colloidal Particles

It is possible, on the other hand, to prepare polymers of high molecular weight, capable of giving colloidal solutions. We begin wth butadiene, styrene and isobutylene, and obtain polymers of over 1000 mol. wt. when working at very low temperatures (around —30° to 80° C.) in the presence of boron fluoride.

These colloids, used in small amounts considerably enhance the viscosity and above all, the viscosity index of ordinary lubricants. The properties of "voltolised" oils are due in part to the presence of large micelles.

In practice, the polymerization is followed by precipitation with some chosen solvent obtaining fractions of molecular weight of over 5000. Beginning with isobutylene one can obtain molecules averaging about 40,000 mol. wt.[17] Using certain vegetable oils one can also obtain similar colloidal micelles.

Finally, one can use certain colloidal and oily compounds at the same time. For example, as in polymerizing unsaturated vegetable or animal or mineral oils in the presence of small amounts of sulphur, selenium, or tellurium; the results obtained in this field are excellent and such products will continue to be used after a return to normal conditions.

Emulsions of oil in water are related to colloidal solutions. The problem of stabilization of these emulsions is practically solved, and Brillie has shown that it is possible in many cases to realize a saving of 60-75 percent of oil.

One can finally add to oils or to emulsions such mineral colloids as graphite, clay, or similar material. In the case of graphite a transformation of the metallic surface takes place resulting in graphoidal surfaces in extremely thin layers. In the case of colloidal clays their use is more often a question of last resort and always results in a rapid deterioration of the bearing surface.

Boundary or Oiliness Lubrications

Certain compounds possess the property of forming thin films adsorbed on the metal surface—films from which radiate small molecular fields of force. These compounds should be di-symetrical and should contain a polar group at one extremity of the molecule and a non-polar chain at the other. The polar group orients itself on the metallic surface; the non-polar group will extend away from the field of superficial force; the whole results in new surfaces actually being built up, layer upon layer.

Unfortunately it is difficult to specify beyond this the reasons for some of the qualities of these thin adsorbed films. It is evident that the molecule ought to be long in order to form quite a thick monomolecular film or shield, and that the materials or the surface show appreciable dipole moments. Various chemical groups arrange themselves in the following descending order: carboxyl and sulphur groups, double bonds, hydroxy, and finally ester groups.

However, the film may consist of many thicknesses of molecules, without one being able to establish any distinct relation between the number of molecular layers and the chemical structure of the compound added to the lubricant.

Finally, the stability of the film depends on geometrical factors. Woog[18] has revealed the role of molecular volumes and the homogeneity of the product. The "wedging" of molecules is the more perfect as the average molecular volume increases and rests on as many points as possible of the surface it is to protect. Heterogenity of the lubricant is shown to be undesirable for a strong lasting film, which is desired to be as homogeneous as possible.

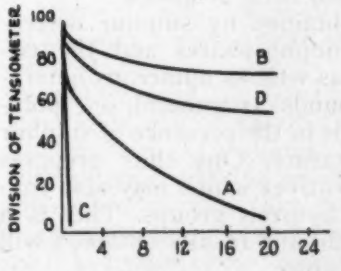
To sum up, we must construct a layer almost crystalline in structure, very compact and solidly adsorbed to the surface of the metal. To increase the oiliness of a mineral oil it suffices therefore to add small amounts of oiliness compounds which form one or more molecular layers on the rubbing surfaces to be protected.

It was usual practice to add traces (1 percent) of castor oil stabilized by triethanolamine or small quantities of aluminum stearate or palmitate lead to lubricating oils. The interest of such oils as "Castrol," for example, is that it possesses these oiliness agents.

Briefly, the surface molecular field is appreciably diminished by the screen of adsorbed films. It results in a noticeable reduction in the coefficient of friction. While the film of oil separating the surfaces becomes thinner at the sliding surfaces or interface, it is the oiliness property which comes into play.

The methods which indicate the existence of these films are numerous. We recall the work of Trillat,[19] Marcelin,[20] and the outstanding work of Woog already cited.

Trillat measures the surface tension of a water-oil interface and determines the variation of this quantity as a function of time. If adsorbable polar compounds are present in the oil these will gather gradually at the interface and the surface tension will slowly decrease. If the oil being analyzed is passed through a filter paper or through metal balls, polar compounds



A—Test oil plus 1/2800 oleic acid.

B—Oil A after passage through one paper filter.

C—Test oil plus 1/500 oleic acid.

D—Oil C after contact on hour on two papeer filters and filtration through a third.

FIGURE 2

are removed by adsorption to a considerable degree; the new curve obtained on the recorder of the tensiometer will be above the preceding one. This method shows the importance of a judicious choice of treatment oils should be submitted to in order not to remove their "oiliness" components. (Figure 2)

Marcelin measures the friction directly on a recording machine as a function of the speed. On one of these "friction grams" (see Figure 3) we observe a part of a sinusoidal curve in various steps, the steps

being inversely proportional to the speed (the sheet is moved uniformly; the curve is made by a stylus mounted on a shaft). The ordinate of this curve is also proportional to the friction. We observe three distinct parts about this curve. At the beginning, a series of sharp curves correspond to high values of

FIGURE 3

the coefficient of friction. It is the oiliness operation; the various ordinates correspond to the different layers of molecular films. The middle part of the curve shows, on the contrary, a coefficient of friction almost proportionate to the speed. This is a characteristic of hydrodynamic lubrication.

Finally, one notes that the coefficient of friction is almost independent of the speed and quite low at low speeds—the interpretation of which is questionable. According to Marcelin, there exists a lubricating layer of minimum thickness whose stability he explains by analogy to a soap bubble which contains fatty matter floating on its surface. The whole surface consists of a mono-molecular layer of oil. The excess of oil gathers in drops of definite thickness, regardless of the amount of oil in excess.

It remains to explain how a polar compound can form films of one, two or more molecular thicknesses and without transition form a layer of minimum thickness greater than 30u. In any case, it is sufficient to know that certain unsymmetrical compounds form solid layers. The problem is one of synthesizing of such compounds.

One can prepare fatty oils similar to the vegetable or animal oils used in compounding by a synthesis wherein the paraffins are oxidized with oxygen in the presence of catalysts of cobalt or manganese. One such method leads in general to oxy-acids which form thin layers very resistant to high pressure. One can also utilize the higher fatty alcohols obtained as products in the hydrogenation of carbon monoxide; (processes for methyl alcohol or "synthol") the utilization of synthetic esters (from acids with more than six carbon atoms and alcohols with less than five carbon atoms) has also been proposed.

But best results are obtained by sulphur derivatives, such as the tri-thiophosphates and the trithiocarbonates of alkyls, as well as numerous heterocyclic sulphurized compounds. In general, one polymerizes certain compounds in the presence of sulphur at quite a high temperature. One thus prepares heterocyclic sulphur derivatives which may also contain nitro, carboxyl, or hydroxy-groups. This is a truly organic chemical field and results obtained will be of great value in the future.

The affinity of sulphur for metals has been known long before this action was understood. When a bearing began to get hot one added sulphur to the oil and attributed the better lubrication to a light polish formed on the metal. In reality, it produced a superficial sulphided surface, weaker in molecular field and also unctuous. Carbiding of metals offers analogous advantages; in the cast product this state of iron exerts the lowest coefficient of friction.

The future field of study here is exceedingly large and Marcelin's work has greatly contributed in this service. We have called attention above to the advantage of the addition of colloidal graphite. It is a matter of forming a durable, if not permanent, union of graphite with metal. On such graphoidal surfaces one can easily use lubricants which are devoid of polar compounds.

Colloidal graphite solutions are made by incorporating in the oil (by simple agitation) 10 percent of graphite initially to form the graphoid surface; later for normal lubrication one employs a 2 percent mixture.

One may ask is it possible to form oily surfaces by using low-viscosity oils; such oils prevent a loss of energy given off in the form of heat. Water, therefore, would be an ideal lubricant. In fact water is used to lubricate certain surfaces in plastics manufacture. Thus, water is used on "celoron," a rosin used in coating sheaths of textiles or metals in the manufacture of roller bearings, etc., where the coefficient of friction is about 0.04 at a pressure of 210 kg/cm² at speeds of 0.25 meters per second.

For speeds close to 1 m/sec. the coefficient of friction can be lowered to 0.005. Moreover, one can add oil products to the water, such as certain soaps or more generally, employ soluble oils or emulsions.

Conclusion

The chief purpose is to produce lubricants from available raw materials. One can polymerize toluol and xylol with sulphur under certain conditions which leads, as one can foresee, to oils which are very viscous in the cold and of very low viscosity index. Most of the synthetic products are used to replace the natural products which have become scarce, or with newly developed oils. Thus, resin oils obtained by decarboxylation of resin and treated (if necessary) with hydrogen in the presence of an hydrogenation catalyst, are very much in demand as lubricants. Unfortunately, in France their production has fallen off to 55,000 tons (it had been 75,000 tons). The problem consists mainly in distribution of raw materials, expert choice of blends, and a balance between diminishing quality and increasingly greater demand.

The studies which we have summarized give some exact data on the problem. But their value goes beyond this limited outline. Our knowledge today of the mechanism of lubrication allows one to modify a product considerably by a reasonable addition (in small quantities) of oily compounds, colloidal materials, paraflow, and many other additives. Many syntheses utilize paraffinic and aromatic by-products. Technical interest is thus closely associated with the scientific value of the results which we have described.

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X-Ray Diffraction

ARTICLE 2
Constitution of Matter

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AS WAS explained in the previous article, the nature of the atom or groups of atoms representing the points of a lattice is responsible for the lattice dimensions. These dimensions are held by interplanar forces that vary with different types of structure. According to Bernal, and others, crystals can be listed according to the bonding forces, into several different types, each with physical characteristics common to that group. These relationships are considered below.

The simplest relationship between atoms is the attraction between ions of opposite sign. The magnitude of this force between ions is determined by their valence and the distance between the particles.

Elements whose ions are large, and ionization potentials low, tend towards acting as cations. Small ions will tend to form covalent bonds while the negative ions tend to form acid radicals. Some crystals of this ionic class are NaCl, CaF_2, LiCl, all of which have some common properties, such as tendency to fracture by cleavage, fairly high melting point, moderate electrical insulation, and transparency to visible light.

Certain minerals such as diamond (C), carborundum (CSi) and zinc blende (ZnS) demonstrate strongly the presence of the covalent bond. When two electronegative atoms are linked together by a covalent bond the systems of electrons inter-penetrate and consequently a more closely bonded structure or close-packed system is prevalent.

The presence of homopolar binding is indicated by extreme insolubility and great hardness. High refractivity in the optic region and a very high melting point also are common.

In metallic crystals, the valence electrons cannot be considered as tied to any particular atom but must be looked upon as a kind of electron gas. Metallic types of crystals are said to be bonded by electrical attraction between this electron gas and the positive ions, and are distinctly different in their properties from elements with either the ionic or covalent type of bonding. This concept is attributed to Drude, who assumed that metals contain a number of free electrons, the motion of which is that of an ideal gas. The elements in this group are conductors of electricity with their conductivity directly proportional to the number of free electrons and also to the heat conductivity. They have a medium to high melting point range and a hardness varying from medium to very hard. Examples of these types of crystals are Au, Cu, Zn, Mo, Na, etc.

The molecules of many organic compounds, each with its own internal system of bonding, can pack together as low-melting-point, soft crystals. The forces that hold these molecules together are called van der Waals or molecular forces. They are due to residual electrical fields between molecular poles. Paraffins (C_nH_{2n+2}), and carbon dioxide (CO_2) fall into this category. They are normally good insulators to electricity and have low melting point. They also usually are transparent to visible light.

Silicate chemistry has always been very complex and somewhat without order until X-ray diffraction cleared up the difficulties. Substantially, the chemistry of silicates has now become, a geometry of silicates.

Silicon is always found between four oxygen atoms and can exist in a number of forms.

1. Independent $(SiO_4)^{iv}$ groups (ortho-silicates)
2. Closed system such as two tetrahedra linked to form $(Si_2O_7)^{vi}$, 3 in ring formation to form Si_3O_9, 4 to form Si_4O_{12} or 6 to form Si_6O_{18} (diortho-silicates)
3. Endless chains, either single $(SiO_3)^{ii}$ or double (Si_4O_{11}) (meta-silicates)
4. Sheets of linked tetrahedra, each sharing three corners, (Si_4O_{10}) (dimeta-silicates) (micas and talcs)
5. Three dimensional networks of the form $(SiO_2)^0$, sharing 4 corners, (silica type)

The above classification is, however, somewhat confused by the fact that complexes of silicon and oxygen with other elements are quite common in nature. For instance with magnesium in olivine. Mg_2SiO_4, or aluminum in cyanite Al_2SiO_5.

Elements other than silicon can also demonstrate silicate-like bonding as in spinel Al_2MgO_4, and corundum αAl_2O_3.

Another form of bonding occurs in the case of metalloids of the sulphur, arsenic type, which is a combination of covalent, ionic and metallic bond, and consequently the properties of compounds with such elements can vary considerably. This bonding is called *metalloidal* and is demonstrated by materials such as pyrite FeS_2, nickel arsenide, NiAs, etc.

Particle Size

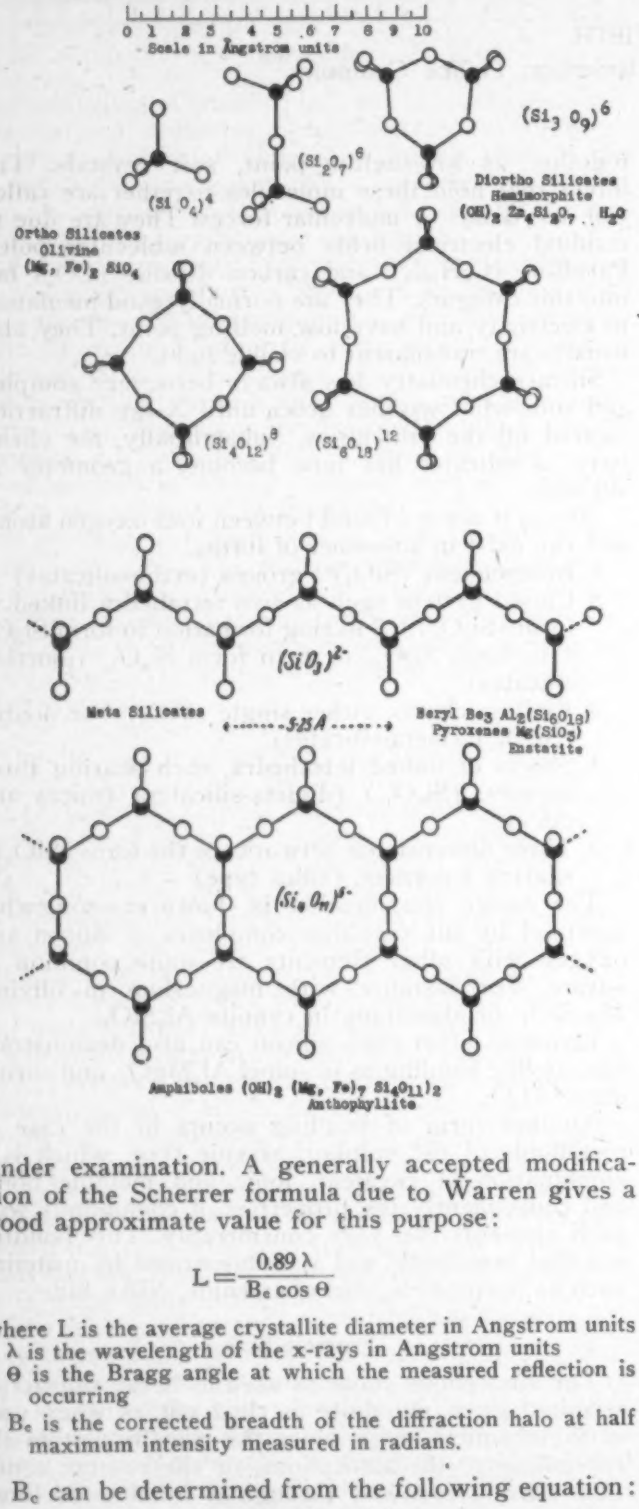
The amorphous stasis as used in X-ray diffraction terminology is not quite as clear cut as when used in the chemical sense, since the transition from the crystalline to the amorphous, or the reverse condition can be followed through a number of intermediate stages in certain cases.

If a powder diagram be taken of a crystalline powder under optimum conditions for resolution, it will be seen that the lines are very sharp so long as

the individual crystallite size does not fall below a certain value.

If, however, the individual particle size falls below about 500 Å in dimension, the lines will be seen to become diffuse; the smaller the particle size the more diffuse the line, until only a very broad halo band will be present.

By measurement of the width of this halo it is possible to compute the particle size of the material



under examination. A generally accepted modification of the Scherrer formula due to Warren gives a good approximate value for this purpose:

$$L = \frac{0.89\,\lambda}{B_e \cos\theta}$$

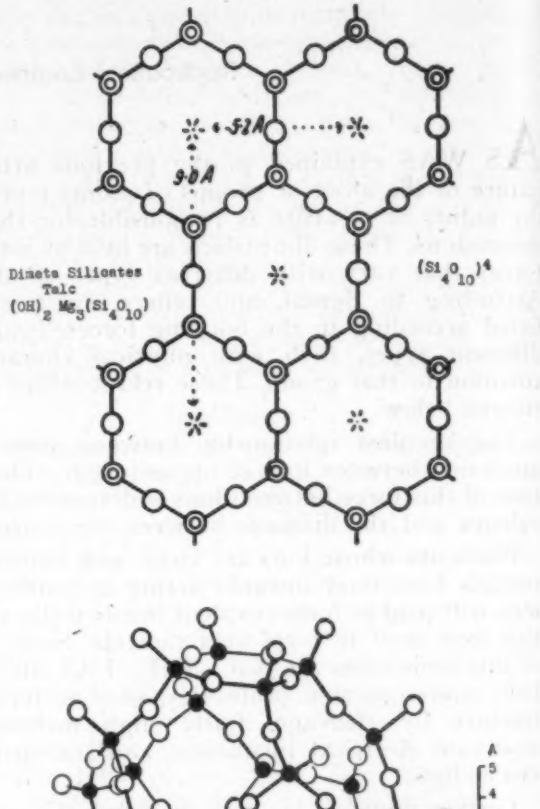
where L is the average crystallite diameter in Angstrom units
λ is the wavelength of the x-rays in Angstrom units
θ is the Bragg angle at which the measured reflection is occurring
B_e is the corrected breadth of the diffraction halo at half maximum intensity measured in radians.

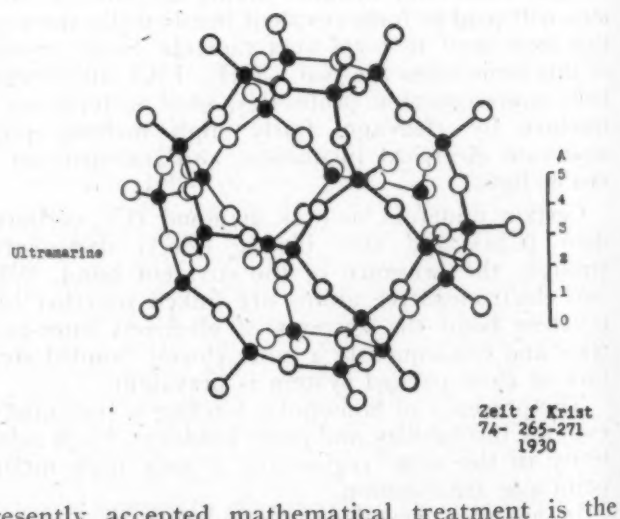
B_e can be determined from the following equation:

$$B_e^2 = B_o^2 - B_c^2.$$

B_o is the measured width at half maximum. B_c is the width at half maximum given by a well crystallized material at the same reflection angle. This is really a correction for the experimental conditions.

For the range of particle size measurement below 100° however, it is much more convenient to utilize the low angle scattering from the specimen and measure the angular intensity distribution obtained. This method under most conditions will give a good value that can be correlated with other physical data. A number of papers by Guinier, Kratky, Warren, Fankuchen, and others, cover this subject and the





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presently accepted mathematical treatment is the following given by Warren: $I(\theta) = Ke^{-\frac{(4\pi \sin\theta)^2}{\lambda} \frac{R^2}{5}}$

$I(\theta)$ = intensity at an angle 2θ from the primary beam
R = radius of particle in Angstroms

It is thus possible to compute a particle size from a knowledge of the angular distribution of x-ray intensity scattered at low angles. The problem becomes more complex when a distribution of particle sizes is present, but, nevertheless a good idea as to the approximate distribution of particle sizes can be obtained by a suitable analysis of the data.

Orientation

A random arrangement of crystals as is usual in a micro-crystalline powder, will give a diffraction cone that is continuous and is represented as a uniform circle, when it intersects a flat film. If, however, the

crystals do not retain their random arrangement but become orientated in preferred directions, the circle is no longer of uniform intensity. Instead, it consists of long or concentrated arcs depending on the extent of orientation present. In extreme cases of preferred orientation the line will be broken up into a series of discrete spots of intensity maxima, that characterizes this condition.

Organic materials can demonstrate preferred orientation to an astounding degree, particularly in some natural fibre material, and natural or synthetic high polymers, where the degree of orientation can be correlated with mechanical properties.

In metals and alloys the degree of orientation present is of great importance in the determination of the physical state of the metal prior to or after working. In the case of drawn wires of all body-centered cubic metals the (110) plane has always been found orientated in the direction of drawing. With face centered cubic the (111) plane is often orientated along the wire axis although (100) orientation is also found. If drawing is persisted in with orientation present, the wire becomes very hard, and does not draw easily, and may consequently break.

Alloy Formation

If two or more metallic substances are mixed together in a fluid state and allowed to solidify, a number of different conditions can occur.

1. They may each separate out as crystals of each individual component.
2. They may dissolve one in the other to form a solid solution or alloy.
3. They may form intermediate phases.
4. One or the other may change to another allotropic form.
5. A combination of any of the above can occur.

For one metal to be soluble in another, so that they form a continuous series of solid solutions, they must have the same crystal structure, similar electron configuration, and not differ in size by more than 10 percent or so.

In certain cases the solubility of one metal in another is a sensitive function of the temperature and upon lowering the temperature of a hot alloy to that of the room, the excess of the solute will precipitate out as another phase or combination of phases that can change the physical properties of the alloy considerably.

Take the system of brasses for instance, where zinc is added to copper, so that the zinc atoms replace copper atoms in the lattice. After 32 percent of zinc has been added to form α brass, the solution in copper is saturated, and the addition of more zinc forms a different type of lattice, the so-called β phase. Above 60 percent of zinc the γ phase, and above 80 percent the ϵ lattice is found. If the zinc content exceeds 87 percent a solid solution of copper in the zinc lattice is formed.

Each of these intermetallic phases can be recognized by X-ray diffraction diagrams, and by accurate intensity measurements of the diffraction lines, a quantitative determination can be made.

Since the physical properties of the metal depend on the phases present, their distribution and the type of orientation, all of which can be determined by diffraction data, it follows that this information can be of increasing importance in metallurgy.

Organic Compounds

The study of organic compounds is of somewhat greater complexity than equivalent work on inorganic materials, mainly because of the more complicated nature of the molecules, high molecular weight and usually low symmetry.

The concept of the tetrahedrally-linked carbon atom and of the six-membered benzene ring are two of the fundamental ideas of organic chemistry which can be clearly demonstrated by X-ray diffraction studies.

Because carbon, oxygen and nitrogen show comparable scattering power for X-rays, their differentiation is difficult. It is also impossible to derive directly the positions of hydrogen atoms since they do not scatter the radiation appreciably. If higher-atomic-weight elements are present as in the organometallic materials, the determination of the complete structure is often considerably simplified.

In the case of a homologous series, if the structure and symmetry of one member has been determined, the structure of the other members can be deduced by analogy, of the different physical properties which can be accounted for by the addition, subtraction or substitution of some constituent part of the molecule.

The aliphatic long-chain series tend to build up so that the long-chain molecules are parallel to each other and because the molecule ends tend to line up and form sheets, of a thickness of the order of magnitude of the molecular length, the repetition of these sheets will give a large X-ray spacing value. The relative strength of the orders of reflection can be correlated with the structure of the sheets and can be done in any other similar system in which the fully extended chains are normal to the sheets.

In the paraffins and in similar systems of fully extended long-chain molecules, in which the molecules are normal to the sheets, it has been shown that the spacings of the first orders of X-ray reflections by the planes of the sheets have increments of 1.25 Å per carbon atom in passing from member to member of the series.

Thus a measurement of the long spacing of an homologous series, can be used to identify the material, and simplify a molecular weight determination.

The way in which foregoing concepts are used in diffraction studies will be described in Part 3 of this series.

Ceramic Linings For Acid Tanks

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TANKS and vessels for acid handling and storage long have been a problem of the processing industries. Research and practical experience have combined in arriving at the conclusion that one practical solution of this problem is a vessel lined with ceramic which will withstand action of acid at the required concentration and temperature. The tank of this type consists of an outer shell of steel or concrete which is protected on the inside by a lead sheathing or an impervious acid-resisting plastic coating, and an inner lining of acid-proof brick. This brick lining may be 4 to 12 inches thick, according to the acid to be handled and temperatures involved. The brick are jointed with an acid-proof cement, either sulphur-base, silica-compound or resinous. This type lining imposes no restrictions upon the shape of the vessel.

The outer shell serves only as a support and does not need to be acid-proof. The membrane with which the shell is covered must be impervious and acid-proof, but is not subjected to wear. The brick lining must be both acid- and wear-proof, but it is not impermeable to liquids. The combination of construction results in a strong acid-, wear- and leak-proof vessel. Thickness of the brick lining is according to requirements of structural strength, and protection of the elastic membrane from mechanical damage as well as extremes of temperature.

For shallow tanks operating at temperatures to 150° F., a single brick lining of 4 inches will suffice. Under similar temperature conditions, large and deep tanks require 8- to 12-inch brick lining for mechanical strength. By the same token, smaller tanks subject to constant high temperatures may require brick lining heavier than needed for strength, to protect the membrane from heat.

The type of construction outlined is suited to all acids, with variations in material. Suggested materials for handling sulphuric, hydrochloric, hydrofluoric and nitric acids (the most commonly used commercially) include:

Walls under construction show how acid-proof brick lining is built to protect impervious membrane from wear and extremes of temperature.

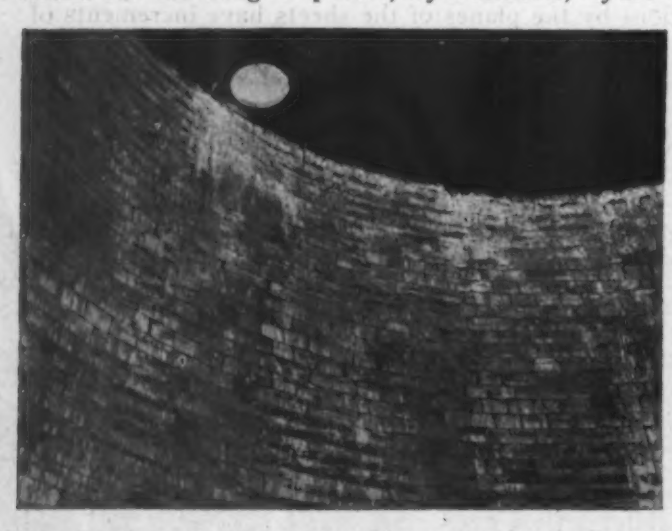
Membrane: Rubberized asphaltic compounds or properly selected synthetic rubber for all four acids; rubber for all except nitric acid, or lead for sulphuric acid.

Brick: Carbon brick for all acids; silica brick for sulphuric, hydrochloric and nitric acids.

Cement: Sulphur-base cements for all four acids up to 200° F.; resinous cements for sulphuric, hydrochloric and nitric acids up to 275° F.; silica cements for sulphuric, hydrochloric and nitric acids of not less than 5 percent strength and up to several hundred degrees temperature.

When, as sometimes occurs, it is necessary to operate a tank alternately with acids and caustic, an acid- and alkali-proof resinous cement is used for jointing compound, with brick and membrane according to type of acid used.

Other points to be considered in acid-tank construction include provision for expansion, heating and drainage, protection of outside of tank against spilling, and protection of floors, sewers and gutters.



These two views show top and bottom of interior of steel oil-storage tank in refinery service, the steel shell being protected by acid-proof brick.

Chemical Utilization of Natural Gas

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THE accompanying text was prepared as a report to the Technical and Research Committee of the Natural Gas Department of the American Gas Association. As such it becomes an attempt to point out those ways in which natural gas is used in addition to its principal use as a fuel and source of energy. Greatest weight is placed upon those uses which take the greatest volumes, and other uses have been mentioned briefly. It points out that the present principal uses as a group probably will not consume as much natural gas in peacetime as they do at the wartime peak, that the minor uses probably will grow but cannot conceivably increase enough to become really important from the standpoint of natural-gas consumption. Nor does this discussion make marked division between natural gas as such and refinery gases in chemical uses.

The data on volume should interest those who have visualized early exhaustion of the supply of natural gas upon which a new chemical industry is to be based.

Finally, attention is directed to the Fischer-Tropsch process which can be used to make motor fuel from natural gas, and which may develop into a major use for gas.

ALL THINGS, the ancient philosophers believed, could be expressed in terms of four elements: fire and water, earth and air. Today we still find it convenient to use two fundamental concepts, matter and energy, although Einstein has taught us they are but differing aspects of a single entity. Natural gas is important primarily as a source of energy, a convenient fuel, and only in a relatively minor way as matter to be used or transformed. It is with this minor use of natural gas that the present report is concerned, with what one can do with natural gas besides burn it.

To say that the annual production of natural gas is of the order of four trillion cubic feet may give some idea of the amount of matter with which we are concerned. It may be helpful to point out that this quantity of gas weighs about 100,000,000 tons and thus on a weight basis the natural-gas industry has an annual production about equal to that of the steel industry.

Chemically speaking, natural gas is a mixture of compounds, predominantly hydrocarbons, but with minor components including nitrogen, carbon dioxide, hydrogen sulfide and traces of other sulfur compounds, and occasionally helium. So far as I know natural gas is never prized for its nitrogen content and natural-gas nitrogen would be used chemically only where it happened to be mixed with atmospheric nitrogen, the mixed nitrogen being obtained from products of natural-gas combustion. Some natural gas is very rich in carbon dioxide and such natural gas has been processed for the production of solid carbon dioxide, so-called dry ice. Hydrogen sulfide is an objectionable component whose removal has been practiced for some time. Very recently, hydrogen sulfide removed from natural gas has been treated for the production of elemental sulfur. While the amount of sulfur produced in this way is quite small compared to the total sulfur production, the operation is of great interest and may be practiced on a larger scale in the future.

Helium

The remaining minor component, helium, has had considerable publicity because of its use in lighter-than-air craft. When war-secrecy restrictions have been lifted we may learn how large a part the helium-inflated units of our Navy played in winning the battle of the Atlantic. This committee has a special interest in helium because much of the research carried on by the Bureau of Mines in cooperation with the American Gas Association under the sponsorship of this committee was done at the Amarillo laboratory established as part of the helium program; and it was to increase helium production that the personnel formerly occupied in such research was transferred. Helium has other uses perhaps less spectacular. A synthetic atmosphere containing helium instead of nitrogen has been found particularly useful for deep sea divers and others whose work in compressed air exposed them to the occupational disease called "the bends," which is due to solution of nitrogen in the blood when the worker is exposed to the high pressure and bubble formation as the nitrogen comes out of solution when the worker comes back to a normal pressure environment. Helium has also been suggested as a component of anesthesia mixtures and experiments with such mixtures have been carried on in hospital operating rooms. By keeping the atmosphere away, a protective blanket of helium has also made possible a successful process for arc-welding magnesium, which is so active chemically that it combines not only with oxygen but also with nitrogen at welding temperatures.

Carbon Black

The hydrocarbons which are the principal components of natural gas are composed of carbon and hydrogen, the carbon making up 75 percent by weight of methane, the simplest, and greater proportions of the other hydrocarbons. By far the most important of the chemical uses of natural gas from the standpoint of volume is the manufacture of carbon black, and this is also the oldest use of natural gas as a source of matter rather than energy. Hundreds of thousands of tons of carbon black are produced each year from hundreds of billions of cubic feet of natural gas. The carbon-black industry has been in existence for many years but it is still changing and will doubtless continue to change. A definite study of the chemical utilization of natural gas must include consideration of the carbon-black industry. The develop of the carbon-black industry indicates certain trends and illustrates certain economic factors which will be important to a greater or lesser extent in the development of any other industry based on natural gas as a raw material.

Several processes are in use for the manufacture of carbon black, but until recently the channel process accounted for all but a small fraction of the total production. One distinguishing feature of the channel process is the small yield. Less than 5 percent of the carbon in the gas is recovered as carbon black. This low yield has several effects. It makes it necessary to use large volumes of gas to produce channel-process carbon black at a commercial rate. Since the price at which the product sells is relatively low, that is, a few cents per pound for the great bulk of it, only low-priced gas could be used. The money yield as well as the material yield being low, the use of natural gas as a raw material for channel-process carbon black came to be considered an inferior use. The carbon-black industry had to move away from a locality as soon as the price at which natural gas could be sold there for fuel became greater than its value for carbon-black manufacture. In some states the use of natural gas for carbon-black manufacture was restricted by law.

Other processes were developed which produced more pounds of carbon black per thousand cubic feet but the carbon black produced by these other processes was less desirable for the major carbon-black market, that is, for use in rubber tires. The shift from natural rubber to synthetic rubber changed the picture. Carbon black made by other processes, notably by the furnace process, was found to be relatively more suitable for use in synthetic-rubber tires than it had been for use in natural-rubber tires. The spectacular

growth of the synthetic-rubber industry was accompanied by a less publicized but tremendous increase in the production capacity for furnace-type carbon black.

Furnace-type carbon black can be made in yields of 25 percent and higher rather than 5 percent or less. Thus, insofar as furnace black can serve purposes formerly exclusively served by channel black, the carbon-black industry takes on a new aspect. If five times as much product can be made per unit of gas consumed, the value of natural gas for carbon-black production may increase considerably before it hits the ceiling imposed by the market value of the carbon black produced. Furthermore, the high material yield makes it very difficult to consider the production of furnace-type carbon black an economic waste. It may even be that the production of furnace-type carbon black will some day be looked upon as a superior use of natural gas.

Another important effect is that the amount of gas required for a commercial-size plant is much less. A furnace-type carbon-black plant using 5,000,000 cubic feet of natural gas per day is quite large enough to be practical.

Both furnace black and channel black are made by partial combustion of natural gas. Other methods for producing carbon black involve thermal decomposition of natural gas, carried on in such a way that no combustion products are mingled with the carbon black, though heat for the decomposition is generated by combustion. There are various modifications of this general process, and the products of the various modifications have properties differing from channel black and from furnace black, and among themselves. Uses for these thermal-decomposition carbon blacks have also increased. The thermal decomposition process also produces hydrogen, and in some cases the hydrogen is considered the main product and the carbon black the by-product; there will be more about hydrogen from natural gas later.

Cost and Transporation

While the differences among the various carbon blacks are of great importance in connection with their several uses, for the present report it suffices to point out that the various types are not completely interchangeable and therefore price differentials exist and can be maintained. However, research by the various consuming industries is stimulated by such price differentials because the consumer has an incentive to modify his process so as to be able to use the cheaper carbon blacks, which are those made in higher yields. Also, the producers of the lower-priced carbon black are stimulated by price differentials to do research looking toward more nearly perfect control of the properties of their products so as to make them suitable for more varied uses. It seems inevitable that as a result of these developments the average yield of carbon black from natural gas will increase. This will tend to make the cost of the gas itself a less important factor. Furthermore, if yield increases it becomes possible to think of making carbon black near the point of consumption rather than where the gas is cheapest. The cost of shipping carbon black from the points where cheap natural gas is available to the consuming centers may exceed the cost of the gas from which the carbon black is made, particularly in the case of high-yield processes. It would probably be feasible to make carbon black near the center of the consuming market if the yield were 30 pounds per MCF because the cost per MCF of moving natural gas by pipe line to a consuming center would probably be less than the cost of moving 30 pounds of carbon black.

It is thus possible to discern two opposing tendencies. As yield is increased, the amount of gas required for commercial operation decreases so that more locations become possible sites for carbon-black plants. On the other hand, as the yield increases there should be a tendency to move the gas to the consuming market and produce carbon black close to the market. There is also to be considered the matter of by-products or concurrent products. It was mentioned above that hydrogen is produced along with carbon black by some processes and the hydrogen may be used in ways to be discussed below. Now the amount of gas necessary for such a commercial operation may also be relatively small, of the order of 5,000,000 cubic feet per day. However, utilization of the hydrogen may restrict the location of the plant since hydrogen is relatively costly to transport, but there may be locations where both carbon black and hydrogen can be utilized. The possibility exists of producing other by-products along with carbon black. This is more likely to come about if the higher hydrocarbons are used as raw material. It is quite possible to conceive of a process in which ethane-propane mixture from a natural gasoline plant will be partly converted into carbon black, the remainder being a gas having a reasonably high heating value so that it may be put in pipe lines for transportation to fuel markets.

Use of Tail Gas

Two further possibilities deserve consideration. Where furnace-type black is produced, the tail gas has so low a heating value that it cannot be economically placed into pipe lines for transportation to distant fuel markets, and generally there is very little use for it as a source of energy at the point of production. Near a consuming center, however, a large volume of low-heating-value gas may be valuable, so that it may become economically feasible to utilize the tail gas from a partial-combustion carbon black process as a source of heat or of mechanical energy. Then consideration of economic waste could be entirely eliminated. The possibility therefore exists that gas may be transported from a location at which its use for carbon black manufacture would be uneconomical to another location and there converted into carbon black, and the tail gas utilized so as to make the entire process efficient in material use as well as economic.

Natural gas is not the only possible source of hydrocarbons from which carbon black can be made. It is known that carbon black is made from acetylene in Canada, the acetylene being derived from calcium carbide made in electric furnaces from coke and limestone. In England and Germany, according to published reports, carbon black is made from naphthalene or other hydrocarbons derived from coal by carbonization. While it does not seem that electric-furnace acetylene or coal-carbonization by-products are likely sources for carbon black in this country, there is the possibility that carbon black will be made from hydrocarbons derived from petroleum. There have been published reports that carbon black has been made, on an experimental scale, at least, from liquid hydrocarbons derived from petroleum. The cost of liquid hydrocarbons available for carbon-black manufacture has probably been too high to make such a process economical if consideration be given only to raw material. However, if yields of carbon black sufficiently high can be obtained from low-priced liquid hydrocarbons, the saving in transportation cost may make production of carbon black from liquid hydrocarbons at points near consuming markets an economic possibility.

It has already been mentioned that the shift from natural rubber to synthetic rubber has had considerable influence on the carbon-black industry and has caused increased demands for carbon blacks other than channel black. This is not to say that channel black is not used with synthetic rubber; on the contrary, the demand for channel black has also increased, but not to so great an extent. When natural rubber is once more available in quantity, will channel black regain its predominant position or will the improved position of other types of carbon black be maintained? Any answer to this question must be based on some assumption as to the future relation between natural- and synthetic-rubber production. However, it seems fairly certain that manufacturers of other types of carbon black will succeed, at least to some extent, in modifying their products to make them useable with natural rubber to a greater extent than was the case in the past, and the rubber manufacturers undoubtedly will develop means of compounding natural rubber so as to take advantage of the desirable attributes of all types of carbon black.

Taking all of the foregoing into consideration, it would appear that greater production of carbon black is to be expected in the future, but that on the average, the number of pounds of carbon black obtained per MCF of natural gas will also increase, and other raw materials may be used, so that the total quantity of natural gas used for carbon-black production may even decrease. Furthermore, the newer processes for carbon-black production may make possible the use of gas which formerly could not have been considered for this purpose because the amount available was insufficient for commercial operation. Thus it is reasonable to expect that carbon-black production will take less natural gas which might otherwise go into pipe lines in the future than it has in the recent past.

Production of Ammonia

The production of hydrogen by thermal decomposition of natural gas with concurrent production of carbon black may be considered from the standpoint of the carbon black being the principal product or the hydrogen being the principal product. At least one such operation has been going on for many years, the hydrogen being considered the principal product and being used in the manufacture of synthetic ammonia. A plant using about 5,000,000 cubic feet of gas per day and producing 100 tons of ammonia per day is definitely commercial. For such a plant the cost of the natural gas is secondary, since the value of the ammonia produced is so great compared to the value of the natural gas consumed. Low-cost natural gas is undoubtedly desirable but not neces-

sary for such an operation, and if other reasons make it advisable, such a plant could be located at a considerable distance from the producing wells.

When the war emergency required expansion of the production of ammonia from which to produce nitric acid for explosives, natural gas came to mind immediately as a source of the necessary hydrogen. The war emergency plants very largely used another process for hydrogen production, one in which natural gas is reacted with steam to form a mixture of hydrogen and carbon monoxide, the carbon monoxide reacted with additional steam to form carbon dioxide and more hydrogen, and the hydrogen and carbon dioxide then being separated. It has been stated that about half of the emergency synthetic ammonia is produced from hydrogen made in this way. Here again the cost of natural gas is not the most important factor, and plants may be located at considerable distances from the producing wells. It is extremely doubtful that synthetic ammonia production will continue indefinitely at the peak wartime rate. When the production rate drops the consumption of natural gas for this purpose will drop, although there exists the possibility that some plants using natural gas as a raw material may continue to operate while other plants based on coal as raw material may shut down.

The manufacture of hydrogen from natural gas by reaction with steam as first introduced into this country from Germany in connection with hydrogenation as a method of petroleum refining. Hydrogenation, in the sense of the conversion of low-gravity crude oil or of residual oil to motor fuel by hydrogen addition has not come into extensive use, but hydrogenation as part of a process for manufacturing aviation gasoline has become of considerable importance and such hydrogen is largely made from natural gas. The process involves an addition reaction of normally gaseous olefins such as isobutylene and hydrogenation of the resulting liquid olefin. Two isobutylene molecules, or an isobutylene molecule and a normal butylene molecule are caused to join, forming an eight-carbon-atom olefin which is then hydrogenated to form an isomer of octane. Generally a mixture of branched-chain eight-carbon-atom paraffins is obtained, called hydrocodimer.

Aviation Gasoline

For the manufacture of aviation gasoline another process has been developed which uses isobutane extracted from natural gas. This process is called alkylation. Isobutane is caused to react with butylene to form in one step branched-chain eight-carbon-atom paraffins. This process is preferred to the one previously described because it is simpler and because the product is somewhat superior. The demand for isobutane for use in alkylation became so great that the supply available had to be augmented by converting normal butane to isobutane, the conversion process being called isomerization. The manufacture of aviation gasoline therefore uses hydrogen derived from natural gas, isobutane extracted from natural gas and isobutane produced by isomerization of normal butane extracted from natural gas.

In addition to alkylation for four-carbon-atom olefins, it is possible to alkylate isobutane with olefins having fewer or more carbon atoms. This is not generally practiced because the most effective use of isobutane can be made when butylene is alkylated. However, where there is locally an excess of isobutane and a supply of olefins other than butylene, it may be more economical to alkylate the other olefins than to move the isobutane to a location in which there is excess butylene.

The outstanding example from the natural gas standpoint is the production of isomers of hexane. This involves the reaction of ethylene with isobutane. Two general processes are in use, one of which produces principally 2-2, dimethyl butane, also called neohexane, while the other produces principally 2-3, dimethyl butane. The production of neohexane was first established on a commercial basis, but the production of 2-3, dimethyl butane is more desirable. For this process ethylene is prepared by cracking propane extracted from natural gas. Actually a mixture of ethane and propane can be used as raw material.

It is technically quite feasible to dehydrogenate butane to form butylene and therefore aviation gasoline could be made from normal butane by dehydrogenating one part of it to form butylene and causing the butylene to react with isobutane formed by isomerizing another portion of normal butane. However, this process seems not to be practiced, at least not on a large scale. The reason is that butylene is available in large quantities as one product of the catalytic cracking of petroleum fractions.

Another process, also called alkylation, is the addition of an olefin hydrocarbon to an aromatic hydrocarbon. For example, propylene may be added to benzene to form isopropyl benzene, or cumene, which is an important component of aviation gasoline. Part of the propylene used in this operation is made by cracking butane extracted from natural gas.

Another method of converting natural gas hydrocarbons such as butane to aviation gasoline involves cracking to form olefins, then polymerizing the olefins. This method was one of the first used to convert normally gaseous hydrocarbons to liquids, but it is of less importance than others mentioned. Hydrogenation of the polymer improves the quality of the product.

The future use of natural gas and hydrocarbons extracted from natural gas for the manufacture of aviation gasoline on a large scale seems quite doubtful. Liberal estimates place the peacetime market for aviation gasoline at no more than 10 percent of the wartime peak production. A large part of the aviation gasoline is produced by catalytic cracking units and it may be that in the future most aviation gasoline will be so produced. There may be some production from butylene and isobutylene by addition and hydrogenation an described previously. Also some production of aviation gasoline by alkylation from butylene and isobutane may continue. However, oil refineries have always produced some isobutylene, butylene and isobutane since cracking was introduced and the production of such four-carbon hydrocarbons is increased in the catalytic cracking process over what it was in the older thermal-cracking process. From such considerations it would appear that natural gas would contribute very little to the peacetime aviation gasoline market. Nevertheless, some companies who have available large quantities of butane, isobutane, propane and ethane are undoubtedly giving serious consideration to manufacture of aviation gasoline during peacetime in competition with manufacture based on crude oil. Such operations are more likely to be carried on by companies engaged in oil refining as well.

Synthetic Rubber

Synthetic rubber, mentioned above in connection with carbon black is also important in the natural-gas industry as a consumer of hydrocarbons extracted from natural gas. The greater part of the synthetic rubber is made by combination of butadiene and styrene. Butadiene is being made by dehydrogenation of butane extracted from natural gas. Styrene is being made from ethyl benzene produced by the alkylation of benzene with ethylene, the ethylene being produced by cracking of propane extracted from natural gas. However, natural gas plays but a minor part in the synthetic-rubber program. Most of the butadiene has so far been made from ethyl alcohol, and ethyl alcohol has also been used in making styrene from benzene. But ethyl alcohol, while produced by fermentation for the most part, is also made from ethylene manufactured from propane. Of the butadiene which is not made from ethyl alcohol, the greater part is produced from butylene which as previously mentioned is made by cracking oil, primarily by catalytic cracking. One of the largest butadiene-producing plants originally was planned to use butane as raw material. However, it was found that sufficient butylene from oil cracking was available in the neighborhood for the planned butadiene output. Since dehydrogenation of butane to butadiene requires the removal of twice as much hydrogen as dehydrogenation of butylene, the latter is the preferred raw material. If it were not that butylene is in even greater demand for aviation gasoline there would probably be no production of butadiene from butane at all. Therefore, when the demand for aviation gasoline decreases and butylene becomes relatively plentiful, it is reasonable to suppose that butadiene manufacture from butane will cease. The production of styrene using ethylene produced by cracking propane may continue, since the extraction of ethylene from refinery gases is generally more difficult than the extraction of butylene. However, it is to be expected that further developments in processing refinery gases will increase the amount of ethylene extracted, and thereby decrease the production of ethylene by cracking of propane. The foregoing rests of course on the assumption that synthetic-rubber production will continue on a large scale after natural rubber is again freely available. Of course if the production of synthetic should decrease, the demand for natural-gas hydrocarbons for use in synthetic-rubber production would be even less.

There have been considered so far non-fuel uses of natural gas for production of carbon black, synthetic ammonia, aviation gasoline and synthetic rubber. It has been pointed out that carbon-black production probably will increase but that the amount of natural gas required for carbon-black production probably will decrease because greater efficiency in production is to be expected and the tendency is toward the use of types of carbon black which can be made in higher yield.

Synthetic-ammonia-production capacity increased enormously for war purposes, but such production will almost certainly be cut very drastically during peacetime so that the amount of natural gas used as a raw material in synthetic-ammonia production may be expected to show a marked decrease. Similarly, the production of aviation gasoline has increased until present production capacity is enormously greater that would have been considered possible a few years ago. Here again, peacetime demand will be only a small fraction of the wartime demand, and since it is the marginal aviation gasoline which was made from natural gas, generally speaking, the use of natural gas as a raw material for aviation-gasoline manufacture may be expected to decrease markedly if not to disappear entirely. The situation with respect to synthetic rubber is not so clear. Synthetic rubber may continue to be produced in large quantities even after natural rubber becomes freely available, and the use of ethyl alcohol as raw material for synthetic-rubber production will decline. Nevertheless, the production of butylene by cracking oil will probably be more than sufficient to take care of any demand for butadiene for synthetic rubber. It seems safe to predict, therefore, that even if synthetic-rubber production should maintain its present level or slightly increase, the amount of natural-gas hydrocarbon used as a raw material for synthetic-rubber production probably will decrease.

Plastics

The non-fuel uses of natural gas so far discussed have reached their peak of natural-gas consumption or will shortly do so, and in the immediate postwar period such consumption will level off and decline. Other non-fuel uses of natural gas may be expected to become increasingly important. Of these the manufacture of chemical products for use as solvents and for the production of plastics, synthetic fibers, coating materials and the like have had the most publicity although very little definite factual information about the hydrocarbon processing operations is generally available. A half dozen companies are actively engaged in the field of converting natural gas and natural-gas hydrocarbons to strictly chemical products, though the latter are used by many other companies for the production of a vast number of synthetic materials.

In the discussion of such uses of natural gas, it is necessary to distinguish carefully between natural gas and refinery gases. The chemical industry which has grown up on the basis of refinery gases is already very large and growing rapidly. For the most part the olefins are the raw material of this industry. All of these olefins can be made from the natural-gas hydrocarbons and, as already mentioned, some of these are being made. However, it has been well said that a synthetic can never supplant a by-product, it can only supplement it. Olefiins are by-products of oil refining whereas they are synthetics when produced from natural gas. Those companies utilizing refinery olefins as raw materials may find it profitable to supplement their supply by converting natural-gas hydrocarbons into olefins, whereas to compete with olefins which are by-products of oil refining by making olefins from natural-gas hydrocarbons can be economically sound only under very special conditions. For the purpose of this report, therefore, it will be sufficient to point out that olefins can be made from natural-gas hydrocarbons and that they are starting points for a great variety of important chemicals but that such products are more properly considered chemicals derived from petroleum, rather than chemicals derived from natural gas.

Chlorinated hydrocarbons are among the most important solvents and are used very largely for cleaning of fabrics and degreasing of metals. Some of these chlorinated hydrocarbons can be made as readily from olefins by addition of chlorine as from paraffins by substitution of chlorine for hydrogen, so that they are made from both. Others can be produced more readily from olefins, but there are some which can be produced most economicaly from the natural-gas hydrocarbons, and the use of natural-gas hydrocarbons for the production of chlorinated solvents is growing and probably will continue to grow. A large increase of chlorine-producing capacity was generated by the war emergency and much of the new capacity was constructed in the Southwest near supplies of natural gas. It is to be expected that chlorine from these plants will be used to produce chlorinated solvents from natural gas in increasing quantities.

A comparatively recent development has been the production of nitro-paraffins by the vapor-phase reaction of nitric acid with propane. The nitro-paraffins may serve as starting points for a large variety of organic chemicals, some of which have not been commercially available before, while others have been made by more round-about processes at higher cost. Here again the cost of the propane is a relatively minor item, and the operation need not be conducted near the point of production of the propane.

Oxygen-containing organic compounds may be derived from natural-gas hydrocarbons by controlled oxidation with atmospheric air. The possibility of producing valuable materials using as raw material only natural gas and air has intrigued chemists for many years, but it was only within the last 20 years that a successful process was worked out. This process produces principally formaldehyde and methanol, although acetaldehyde and other minor products are also obtained. More recently another oxidation process has reached commercial stature. Its principal product is said to be acetic acid, starting material for acetate-type synthetic fibers and plastics. Butadiene, discussed above as principal intermediate in synthetic-rubber production, contains no oxygen, but a new plant to produce it is said to employ the aldol process, and aldol is an oxygen-containing compound which can be made from natural-gas hydrocarbons by a process involving partial oxidation.

Volume Used for Chemicals

The total amount of natural gas and natural-gas hydrocarbons used in these strictly chemical ways is not very great. It has been estimated that the prewar annual production of methanol, amounting to 20,000,000 gallons, could have been produced from the gas from a single gas well of 10,000,000 cubic feet daily capacity if conversion efficiencies were nearly perfect. Methanol production is now running at the rate of nearly 80,000,000 gallons per year and of course not all of it is being made from natural gas. A recent estimate of the basic raw materials used to produce resins and plastics in 1941 included 690,000,000 cubic feet of natural gas. While the present production rate for plastics may be double that of 1941, and while plastic production may continue to increase rapidly, it is obvious that plastics cannot for many years to come consume more than a very tiny fraction of the natural-gas production. Other specialty chemicals made from natural gas and natural-gas hydrocarbons certainly will be less important from the standpoint of gas consumption, although they may be very important in the general economy from the standpoint of the uses to which the products are put.

It might be suggested that chemical utilization may conserve gas which would otherwise be lost or wasted. Insofar as the manufacture of strictly chemical products may be concerned, this could only be the case if relatively inexpensive manufacturing equipment can be used, if the cost of processing is quite low, and if the volume of gas required for a manufacturing plant is small. A simple oxidation process which produces a saleable liquid product and otherwise meets these qualifications might be helpful from a conservation standpoint; research to develop such a process would be required.

This discussion of strictly chemical uses of natural gas will be concluded by mention of another avenue of approach. It was pointed out above that synthetic ammonia is being made from hydrogen produced from natural gas by a process which involves the intermediate production of a mixture of hydrogen and carbon monoxide. Hydrogen and carbon monoxide can be used as the raw material for synthetic production of methanol as well as higher alcohols, and a large part of the methanol now produced is made from a mixture of hydrogen and carbon monoxide which is made, however, in water-gas machines. It has already been suggested that when the demand for synthetic ammonia decreases, part of the synthetic-ammonia capacity will be turned to the production of synthetic methanol since the plant requirements are in some ways very similar. It is therefore possible to look forward to competition within that portion of the synthetic-methanol industry based on natural gas, with oxidation of natural gas being used to produce methanol directly in some plants, while in other plants natural gas will be used as raw material from which to produce a mixture of hydrogen and carbon monoxide from which methanol will be produced.

In the production of synthetic methanol from a carbon-monoxide-hydrogen mixture it is necessary to use quite high pressures. In studying the effect of pressure changes on this reaction, it was discovered that liquid hydrocarbons could be produced at lower pressures. This was the starting point of the Fischer-Tropsch process which has aroused so much interest in recent years. This process offers a means of converting natural gas into liquid hydrocarbons suitable for motor fuel and thereby a market which could absorb the entire natural gas production. A complete discussion of the Fischer-Tropsch process is outside of the scope of this report, but it may be pointed out that if improvements thought probable by the more optimistic workers in this field should be realized, natural gas would become a more economical source of motor fuel than petroleum. This process therefore deserves careful watching by those engaged in the natural-gas industry.

Fundamentals of Wetting and Detergent Compounds

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Translated by E. J. Barth, Petroleum Technologist

BESIDES the use of oil-soluble detergents as additives to petroleum products there exists a large series of water-soluble compounds used in the textile industry for various applications. These materials must be primarily soluble in water or at least form colloidal solutions. Textile aids possess the fundamental property of greatly lowering the surface tension of water and all possess the property of giving foamy solutions as well as being wetting, washing agents, and detergents. Not all detergents are strong wetting agents, however. For instance, a wetting agent may have a low wetting ability and at the same time show excellent emulsion characteristics; or again, a wetting agent might show only medium detergency and yet be an excellent textile aid.

The greatest number of textile agents that are being manufactured today are organic materials consisting mostly of aliphatic hydrocarbons. These materials can be grouped as follows:

1. Soaps.
2. Turkey-red oils.
3. Sulphonic acids of the aliphatic hydrocarbons and their derivatives.
4. Fatty alcohol sulphates.
5. Cation-active textile aids.
6. Petroleum sulphonates.

Soaps

Soap is not only the oldest but also the most commonly used textile aid employed in the past. Soaps are the salts of high-molecular-weight aliphatic saturated or unsaturated fatty acids containing from 10-20 carbon atoms per molecule. These are combined with inorganic or organic bases, such as sodium, potassium, ammonia, triethanolamine, etc. Most commonly, the fatty acids are derived from natural fats and oils, and the acids such as caprylic, lauric, myristic, palmitic, stearic, oleic, and the like, as well as acids of similar nature containing oxy groups, such as ricinoleic acid. The first five mentioned acids are saturated, the remaining being unsaturated fatty acids.

Below are shown the constitution of two types of soap—one, a saturated soap; the other, made from an unsaturated fatty acid. The first soap is called sodium palmitate:

$$CH_3 \cdot (CH_2)_{14} \cdot COONa$$

The second type of soap is potassium linoleate:

$$CH_3(CH_2)_4CH : CH \cdot CH_2 \cdot CH : CH \cdot (CH_2)_7 \cdot COOK$$

There is a relationship, which is quite close, between the melting point of the fatty acids used in these soaps and the cloud point of the soap solution itself, or the titer of the acid. This is again related to the value of the soap for washing and detergency. The titer is proportional to the melting point of the fatty acid used, which increases with the number of carbon atoms in the molecule. The unsaturated fatty acids melt at a lower temperature than the saturated fatty acids. Soaps made from the unsaturated acids, for example, oleic acid soaps, are more valuable as detergents for use in the cold or at low temperatures. These soaps are strong cleansing agents at 20° C. They are less effective at higher temperatures.

Soaps made from lauric acid show good detergency at medium temperatures—20-40° C.—while soaps made from palmitic and stearic acids function best at the higher temperatures—around 60° C. or above. The potassium and sodium soaps are differentiated as to their cleansing action only in so far as the potassium soap dissolves more readily in cold water than do the sodium soaps, making the former a more efficient cleansing agent.

Soaps are universally used as wetting agents, foaming, and cleansing agents. On the other hand, soaps present several disadvantages. They are very sensitive, generally speaking, to hard water in which they are practically insoluble and therefore are without cleansing action. Even cheap, hard-water soaps will eventually cause spotting and streaking of textiles in the presence of hard water. Calcium soaps have been employed for the use in hard water but most of these also cause streaking due to some precipitation of the soap by this type of water.

The same can be said for magnesium soaps made from the fatty acids. Soaps of iron, copper, chromium, zinc, manganese, etc., are practically insoluble in ordinary water and precipitate out on the sides of laundry kettles and on the textile material in the presence of hard water.

Soaps are very sensitive to acids even in dilute form. Very dilute acid solutions are present in the processing of silk and the dyeing of wool. Finally, soap is unstable in the presence of strong alkalies from which it is actually salted out. Most soaps are also sensitive to salt solutions so that they cannot be used in sea water. There is a strong affinity between the fiber of the textile material and the soap itself, so much so that the fiber will retain small amounts of the soap actually adsorbed upon it, even after careful rinsing. Eventually the textile will develop a rancid odor and show yellow spots during storage.

These many disadvantages of ordinary soap have given great incentive to research in seeking new materials which perhaps may not be designated actually as soaps. There are still many synthetic materials developed in the laboratory, however, which have not entered commercial use due to their high price.

Turkey-Red Oils

To prepare Turkey-red oils one employs oleic acid and castor oil. Treated with sulphuric acid, the latter yields the sulpricinolate, and oleic acid yields the sulpholeate. Sulphuric acid reacts either with liberation of water with the hydroxy group of the castor oil or sulphuric acid may add at the double bond of either the oleic acid or the castor oil. In both cases sulphuric acid esters of oxy-carboxyllic or carboxyllic acids are formed. Finally, sulphuric acid may react with the hydrogen of a methylene group, forming water and sulphonic-acids. The latter form easily when the SO_3 contents of H_2SO_4 are increased, and when sufficient acid is used. Temperature, time of reaction and other conditions come into play also.

The sulpholeate:

$$CH_3 : (CH_2)_8 \cdot \underset{\displaystyle O \cdot SO_3 \cdot Na}{\underset{|}{CH}} \cdot (CH_2)_7 \cdot COONa$$

The Sulphoricinoleate:

$$\cdot CH_3 \cdot (CH_2)_5 \cdot \underset{\displaystyle O \cdot SO_3 \cdot Na}{\underset{|}{CH}} \cdot CH_2 \cdot CH : CH \cdot (CH_2)_7 \cdot COO \cdot Na$$

In contrast to the soaps these products show a certain degree of stability towards acids, alkalies, hard water, magnesium, and sulphate, etc. Due to its solubility in H_2O, of ricino-sulphuric acid, the sulphoricinoleates possess only limited acid or lime stability, which is, however, more pronounced in dealing with the sulphocarboxyllic acids. This stability is greater, however, the greater the amount of H_2SO_4 which has entered the molecule. In other words, is greater with the increase in the amount of sulphoacids formed in the reaction. Sulphuric acid esters decompose by boiling with oil acids into oxy-fatty acids and sulphuric acid while the sulpho-carboxyllic acids resist decomposition.

Sulpho Acids of Aliphatic Hydrocarbons

Sulphonating agents react with oleic acid (olive oil) or castor oil to form aliph sulpho-carboxyl acids. These are termed true sulpho acids. The position of the sulpho group

is still a matter of dispute. One understands, however, that these groups are "internal" sulpho groups.

Aliphatic hydrocarbons (petroleum and its fractions) treated with sulphonating agents form sulpho-acids in which the position of the sulpho-groups in the mole is not definite. The picture is quite different in preparing cetyl sulpho—or so-called cetyl sulphonic acid by the Reychler procedure, $C_{16}H_{33} \cdot SO_3H$, from cetyl iodide by way of the mercaptan: $C_{16}H_{33} \cdot I + NaHS = C_{16}H_{33} \cdot SH + O_2 = C_{16}H_{33} \cdot SO_3H$.

Cetyl sulphonic acid prepared in this manner can only show the following structure: $CH_3 \cdot (CH_2)_{15} \cdot SO_3H$.

Aliphatic sulpho-acids with external sulpho groups are obtained from sulphuric acid esters of the aliphatic alcohols described below by way of the sodium sulphite salts. These compounds also are obtained from saturated fatty acids when the latter are heavily sulphonated, such as with gaseous sulphuric anhydrite. These cetyl sulphonic acids, as such or in the form of an alkali salt, show good foaming properties, wetting and detergent value. These acids are stable toward acids and lime salt and have a good solvent effect on fatty material.

The Fatty Alcohol Sulphates

Aliphatic alcohols are obtained by reduction of the carboxyl group in fatty acids, thus converting the group to the hydroxyl group. For example, from lauric acid one obtains lauryl alcohol. Besides the above hydrogenation procedure one can also obtain high-molecular-weight alcohols by the oxidation of paraffin with air. Or they may be obtained by chlorinating paraffin followed by subsequent treatment with strong alkali. The position of the hydroxyl group in alcohols formed in this manner is not known. By hydrogenation of oleic acid care must be taken that the double bond does not become saturated.

By treating saturated alcohols with sulphuric acid one obtains the fatty-alcohol sulphates.

$$R \cdot CH_2 \cdot OH + H_2SO_4 = H_2O + R \cdot CH_2 \cdot O \cdot SO_3H$$

The reaction of the unsaturated oleyl alcohol with sulphuric acid can be carried out in various ways: the acid can easily combine with the alcohol at the double bond; the hydroxyl group can also suffer esterification with sulphuric acid; or both these reactions can take place simultaneously.

In the first case one obtains the so-called "internal" esters; in the second case the so-called "external" esters; di-sulphuric acid esters are also obtained. Sulphonating agents used for this purpose are sulphuric acid, oleum, sulphuryl chloride, chlor-sulphonic acid, ethyl sulphate, glycerin sulphonic acid, etc. During energetic sulphonation, especially in the case of unsaturated alcohols, one obtains the true sulpho acids.

By treating the sulphuric acid esters with sodium sulphite there are obtained the sulphonic acids (as sodium salts):

$$RCH_2 \cdot O \cdot SO_3 \cdot Na + Na_2SO_3 = Na_2SO_4 + RCH_2 \cdot SO_3 \cdot Na$$

The sulphonates are obtained in the form of the alkali salts, and the lauryl sodium sulphonate is:

$$CH_3 \cdot (CH_2)_{11} \cdot O \cdot SO_3 \cdot Na$$

They are easily soluble in water, showing a neutral reaction and possess a high foaming, wetting and detergent action. They are stable toward acids, alkali, magnesium sulphate and the lime salts. They do not attack the fibers of wool and show great cleansing action in neutral wash waters. These compounds are stable when used in commercial apparatus, such as laundering tanks made of iron, copper, zinc, tin, etc. The di-sulphonic acids made from the oleyl alcohol show a much lower detergency than the above and their wetting power is similar to that of Turkey-red oil. However, Turkey-red oils which contain two sulphuric ester groups are quite stable toward calcium waters.

Cation-Active Textile Aids

In contrast to the above discussed anion-active compounds there are compounds which contain the wetting or detergency "polar group" in the *cation portion of the molecule*. Some of these active materials have not been studied sufficiently to determine their structure; many of the compounds are ammonium derivatives. These materials also comprise compounds consisting of chlor-hydrates prepared by treating chlorinated paraffin with ammonia. The type and length of the paraffin chain has not been definitely determined for compounds of this type.

There are, however, a series of compounds which can be formulated and which are known to have definite constitution, namely the acid amides described by Hartman. These materials are, prepared from the higher fatty acids and ethylene diamine — such as diethylamino-ethyloleylamid. These materials are prepared by heating oleic acid with unsymmetrical diethylene diamine. This base can be used in the form of acetates, chlorhydrates, or lactates. The salts of the basic urethane are also the basis for preparing compounds with ethylene diamine. Salts such as the diurethane of the menthols, or their salts, especially the chlorhydrate, are useful products:

$$\begin{matrix} C_{17}H_{33} \cdot O \cdot CO \\ C_{17}H_{33} \cdot O \cdot CO \end{matrix} \Big\rangle N \cdot CH_2 \cdot CH_2 \cdot \underset{\displaystyle H \atop \displaystyle Cl}{N} \Big\langle \begin{matrix} CH_2 \cdot CH_3 \\ CH_2 \cdot CH_3 \end{matrix}$$

Solutions of these materials are colloidal and behave like soap solutions. They are detergents, dispersing agents, wetting agents, and will emulsify fatty material. Their foaming tendency is much greater than soap solutions. These chemical substances can be salted out with sodium bicarbonate and and the soap base will precipitate when these substances are treated with alkali. These compounds are stable toward metallic salts and also toward salts of the heavy metals. They are very useful for laundering purposes in the presence of hard water. They are also stable toward most acids, and the solutions react practically neutral or at most slightly acid and therefore show none of the disadvantages of ordinary soaps toward wool and silk.

Petroleum Sulphonates

Petroleum and its fractions, as is well known, vary considerably as to chemical composition and physical properties. Mineral oils are quite saturated in most cases although many fractions of petroleum are unsaturated in addition to containing impurities, etc. In other words, the constituents of petroleum contain the aliphatic hydrocarbons, considerable hydroaromatic fractions and, in a few cases, the aromatics.

In working up fractions of petroleum as raw material it must be kept in mind that one is dealing with a mixture of many series of hydrocarbons and practically never with any single chemical substance. In reacting petroleum with sulphuric acid one obtains the so-called petroleum sulphonates. It is especially in this field of preparing sulphonates from oils that this fact concerning mixtures of hydrocarbons rather than chemical entities be well kept in mind.

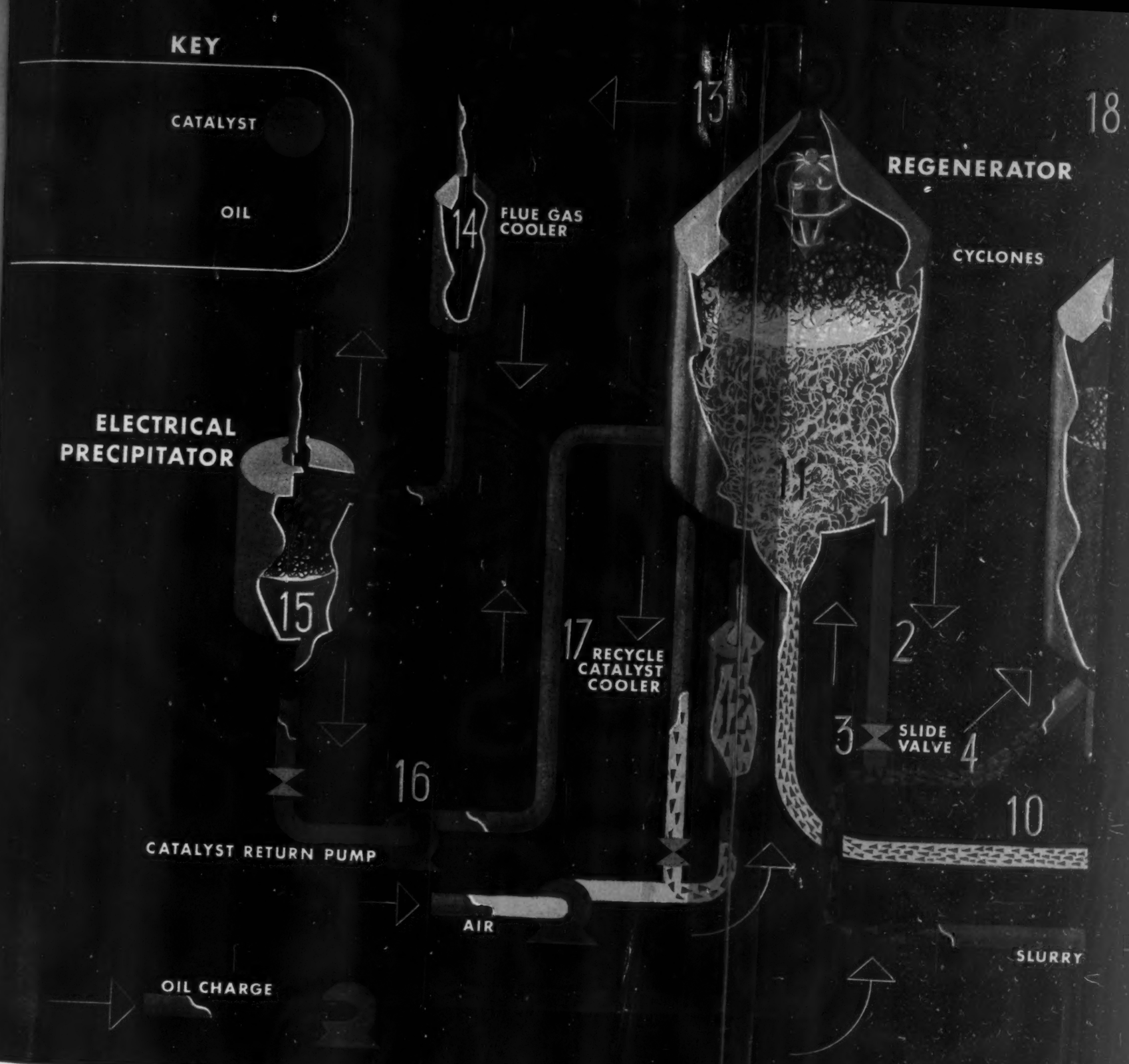
The sulphonation products made from petroleum will consist of aliphatic, naphthenic or even aromatic sulpho-acids, plus a mixture of sulphuric acid esters of aliphatic and cycloaliphatic hydrocarbons and their derivatives. These sulphonates are differentiated according to their properties which are useful in certain specific applications. The petroleum sulphonic acids[1] are obtained chiefly as by-products in any refining procedure where sulphuric acid is employed. It is understood, of course, that oleum and similar sulphonating reagents can be used instead of sulphuric acid. Most often sulphonates and their salts are now manufactured for the sole purpose of preparing these petroleum derivatives for the trade. Where this is the case the oil fractions, type of sulphonating material and special procedures for making sulphonates are carefully studied and have become a truly chemical industry based on petroleum.

The mineral oil sulphonates and their salts, which are called M or mahogany soaps, are used in the main for preparing mineral-oil emulsions. The salts are usually the sodium salts. They are used in mixture with mineral oil also in the textile industry as wool oils. Concentrated solutions of the sulphonates in water are used as degumming agents for raw soap, as softening agents for textile fabrics, and in the dye works for silk, cotton, wool, and the new modern fabrics.

The principal use of the sulphonates from mineral oil as well as from lignite tar oils is as a textile additive for increasing the detergent power, foaming ability, wetting ability, etc., of the processing bath or dye vats in the particular process used in the textile industry. With such a wide application in the many types of processing it is first of all important to discriminate between sulphonates which are oil-soluble and those which are water-soluble.

Mixtures of both types of sulphonates have the advantage that the mixture will show the properties of both types and usually the mixture is a beter detergent or washing agent than either of the sulphonates alone. The water-soluble sulphonates are adapted especially for the cleansing of animal fibers while the oil-soluble sulphonates show greater advantage in washing plant fibers or material derived from vegetable sources.

[1] Chem. Ztg. 64, No. 33-34 (194).



from the catalyst determines the capacity of the entire unit. So it provides the proper point at which to start a description of the process.

① **HOT-CATALYST,** ready for use, is stored in the regenerator and in the

② **CATALYST FEED LINES OR "LEGS,"** down which the catalyst flows to the

③ **OIL FEED LINES.** At this point the hot catalyst is injected into the oil stream. The heat of the catalyst flash-vaporizes the oil reducing the density of the material in the

④ **REACTOR FEED LINES.** The upward movement of the material in this leg is caused by a combination of forces (the pressure head maintained in the regenerator plus the force of gravity exerted on the partially-packed, hot catalyst in 1 and 2) which is sufficient to overcome the opposing combination of forces (the pressure head maintained in the reactor plus the force of gravity exerted on the material in 4 and 5 plus the friction loss during movement in 4). Thus the movement of catalyst-oil mixture into the reactor is caused by difference in densities, without the application of any direct mechanical force, oil pumps serving merely to bring the oil to the point where it is vaporized. Oil-catalyst mixture flows up the two reactor feed lines into the

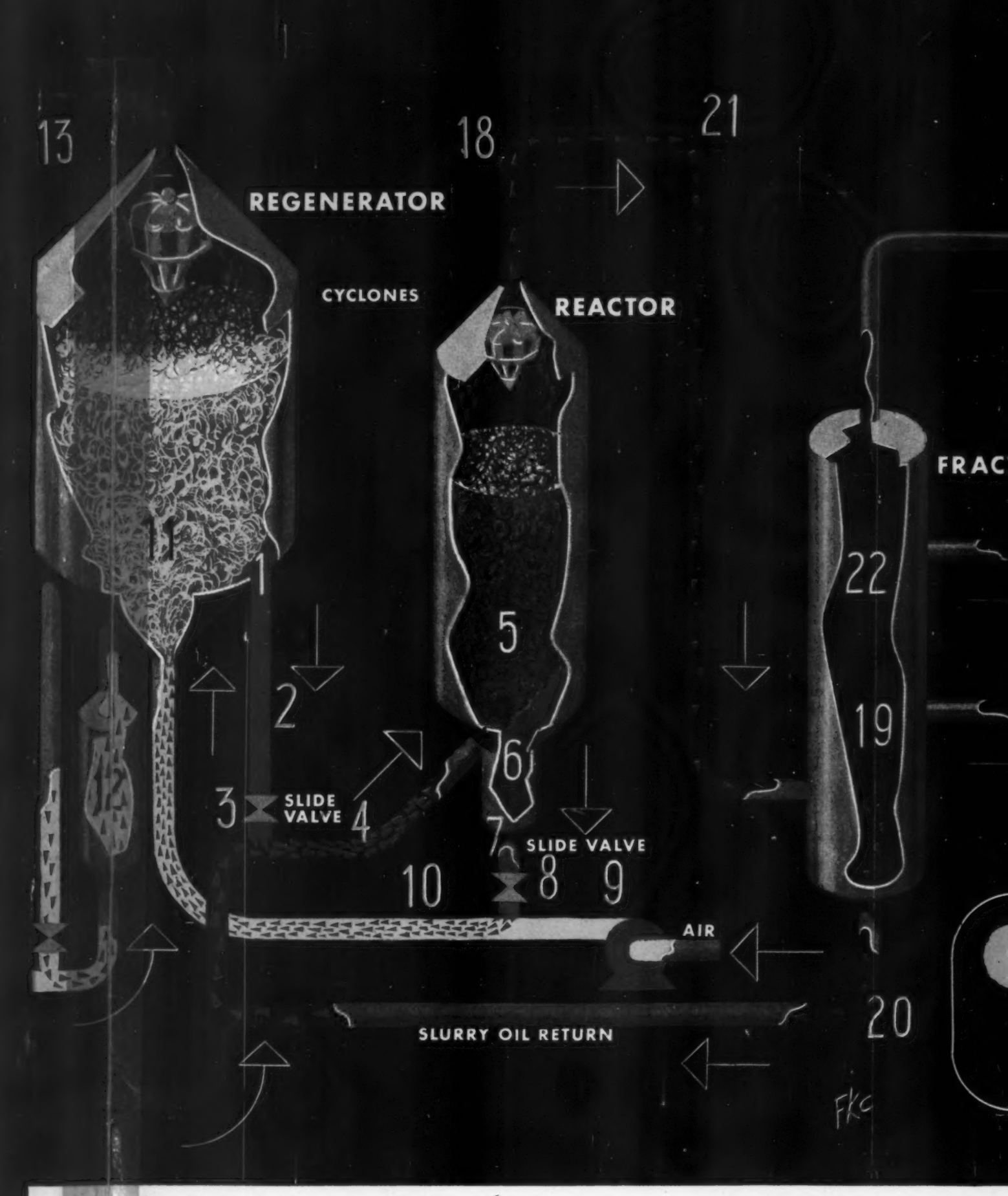
⑤ **REACTOR,** where the mixture establishes a definite level known as a bed. The depth of this bed regulates the time of reaction and can be varied to provide any desired degree of cracking. The feed vapors passing continuously upward through the bed insure proper contact with catalyst. As cracking continues, coke forms on the catalyst and reduces its activity. This spent catalyst continuously separates from oil vapors through the force of gravity, while action is aided by the cyclone separators at the top of the reactor. The spent catalyst then flows through the

⑥ **STRIPPING SECTION** at the bottom of the reactor. At this point the entrapped vapors are released by the stripping medium. (The further course of the oil vapors is traced in numbers 18 to 22. However, as the efficient movement of large volumes of solid catalyst constitutes a major advantage of the Fluid P is now continued.) Fr the spent catalyst f through the

⑦ **DISCHARGE LINE** trolled and maintaine per cubic foot. Spent the

⑧ **SLIDE VALVE,** aft the

⑨ **AIR SUPPLY LINE** the catalyst, reducing in this leg to from



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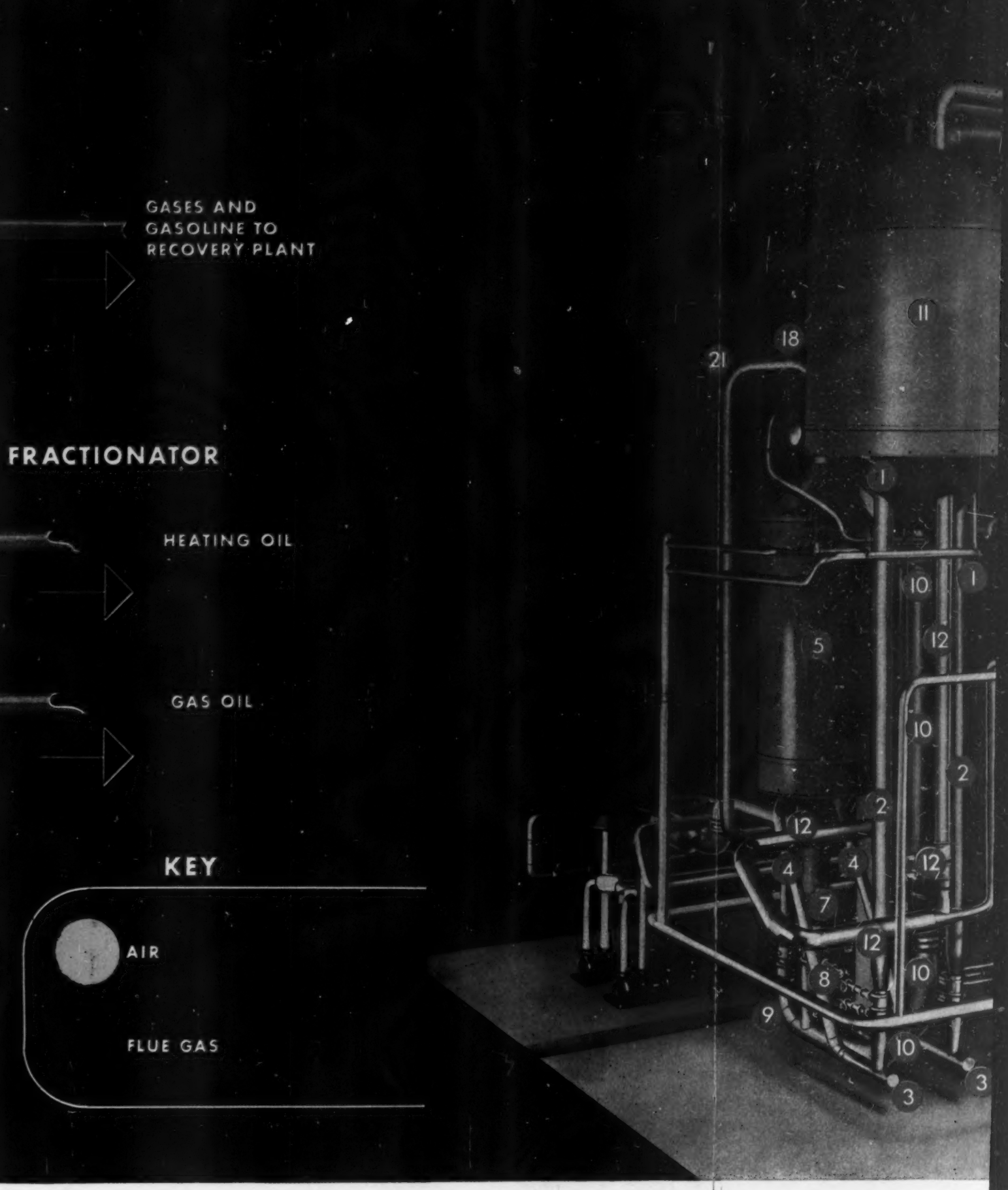
⑦ **DISCHARGE LINE** where its density is controlled and maintained at approximately 25 lbs. per cubic foot. Spent catalyst is released through the

⑧ **SLIDE VALVE,** after which air is injected from the

⑨ **AIR SUPPLY LINE** which aerates or "fluffs up" the catalyst, reducing the density of the material in this leg to from 2 to 4 lbs. per cubic foot. This aeration permits the catalyst to flow as a fluid through the

⑩ **REGENERATOR RETURN LINE.** The upward movement of material in this leg is accomplished by a combination of forces similar to that used in the reactor feed line 4. In this case the pressure head in the reactor plus the force supplied by gravity in 7 overcomes the opposing forces comprised of the pressure head in the regenerator plus the force of gravity exerted on the material in 10 and 11 plus the friction loss during movement through 10. Thus again the actual movement of material is without direct mechanical aid, the air pumps serving primarily as an aerating device, not a propulsion force. Through this line the catalyst moves to the



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11 CENTER SECTION OF THE REGENERATOR, where it again assumes a bed level and where, as in the reactor, the continuous feed of aerated catalyst creates a zone of extreme turbulence. The air which is introduced at 9 is utilized to continuously regenerate the catalyst by burning off coke. Aided by the action of cyclone separators, the regenerated catalyst is retained in the regenerator from which it is constantly withdrawn for re-use. The temperature in the regenerator is governed at all times by the

12 RECYCLE CATALYST COOLER, through which a portion of the catalyst is circulated. The heat given up by this recycled catalyst is used to manufacture steam. The operation of this system is governed by the same principle of differential heads as described in 4 and 10.

The foregoing describes the movement of the main body of the catalyst. While the repeated use of the catalyst continues indefinitely, there are however, two points in the entire system where extra provisions are made to retain catalyst. First provision covers the catalyst that is carried over by flue gas at the top of the regenerator. This flue gas, containing some catalyst, is carried in the

13 REGENERATOR EXHAUST LINE through the

14 FLUE GAS COOLER which manufactures steam for refining use, to the

15 ELECTRICAL PRECIPITATOR, w
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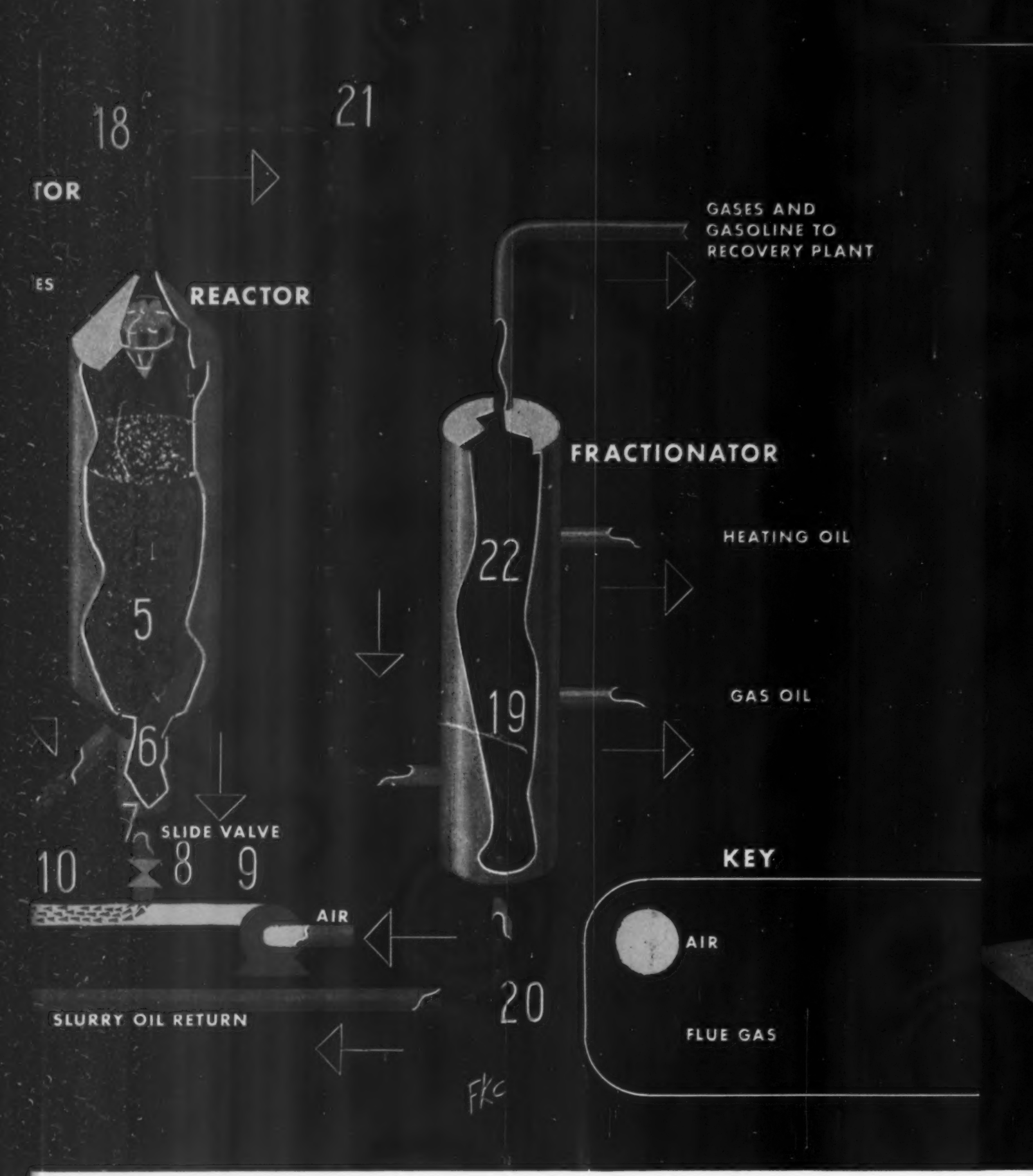

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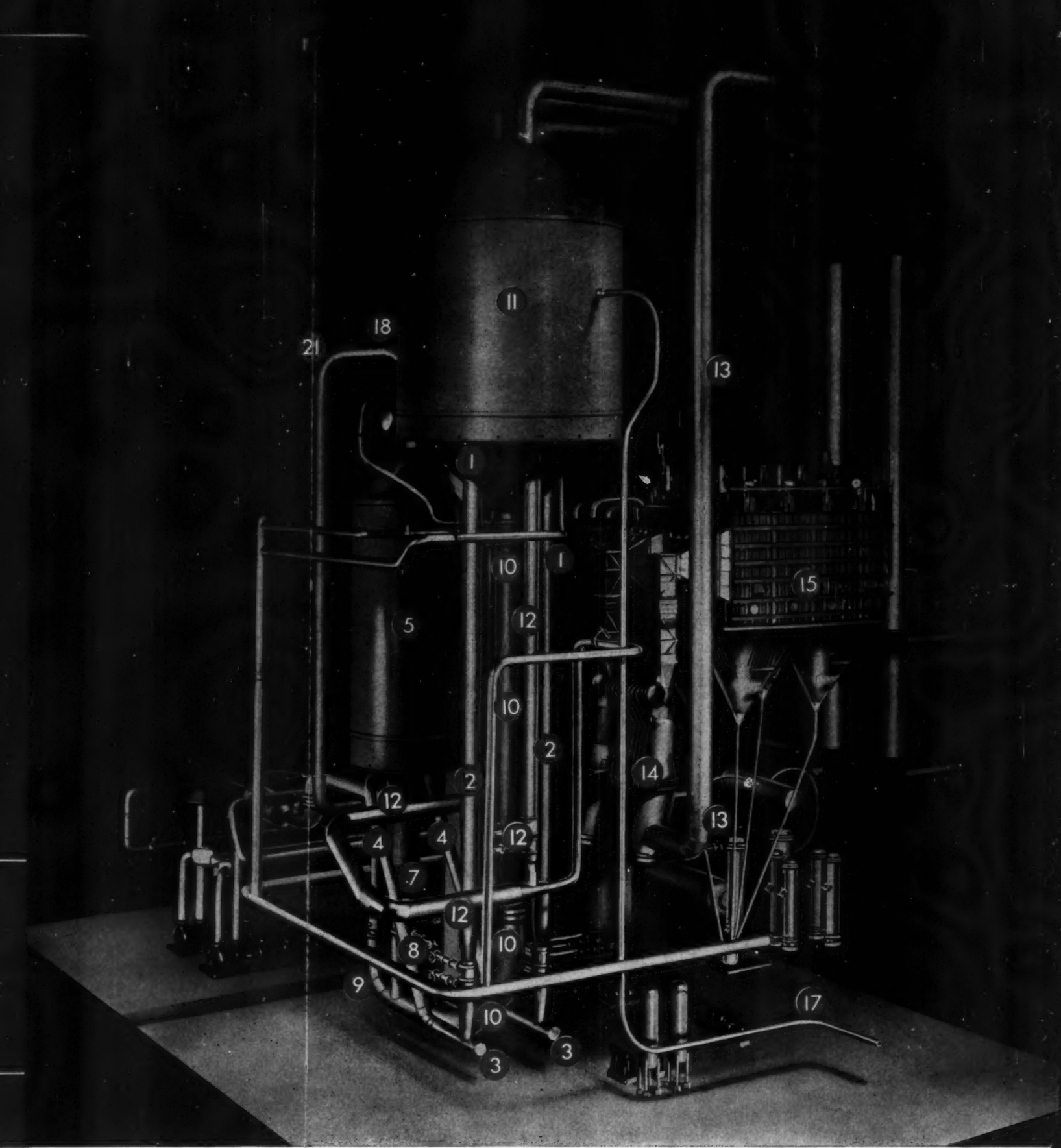

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(15) **REGENERATOR EXHAUST LINE** through the

(16) **FLUE GAS COOLER** which manufactures steam for refining use, to the

(15) **ELECTRICAL PRECIPITATOR,** where the catalyst is separated from the flue gases. The catalyst then flows down to storage from which it is re-fed to the system as desired by the

(10) **CATALYST RETURN PUMP** through the

(17) **FRESH CATALYST FEED LINE**

Second provision covers the catalyst which is carried over with reaction products. This catalyst, which the cyclones have failed to retain in the reactor, flows by the

(18) **REACTOR OVERHEAD LINE** to the

(19) **FRACTIONATOR** where the catalyst is admixed as a slurry with the heavy oil fraction in the bottom of the Fractionator. This slurry is returned through the

(20) **SLURRY OIL RETURN** to the fresh-feed oil line and recycled to the reactor.

To return to the description of the course of the oil vapors, when the cracking action in the reactor is completed, the oil vapors are carried by

(21) **REACTOR OVERHEAD LINE** to the

(22) **FRACTIONATOR** where they are separated into four fractions as follows: (a) overhead, comprising gases and end point gasoline; (b) heating oil; (c) gas oil; and (d) catalyst-oil slurry.

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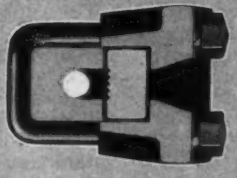

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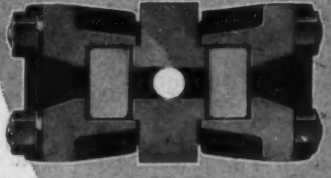

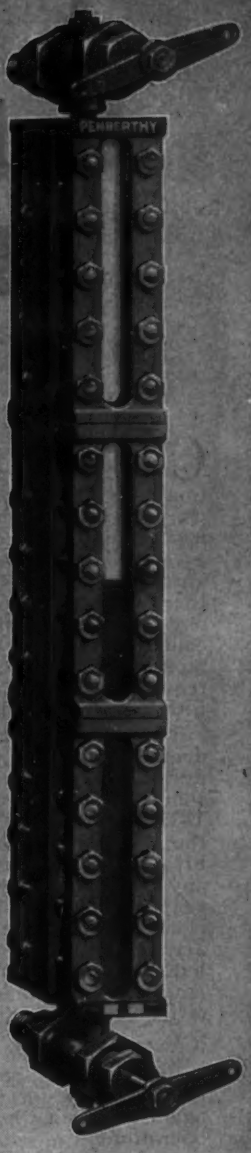

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Water shows black—steam shows white. U-bolt construction is strongest and simplest to service. Glass replaced by simply removing nuts on face of gage . . . unnecessary to work between gage and boiler.

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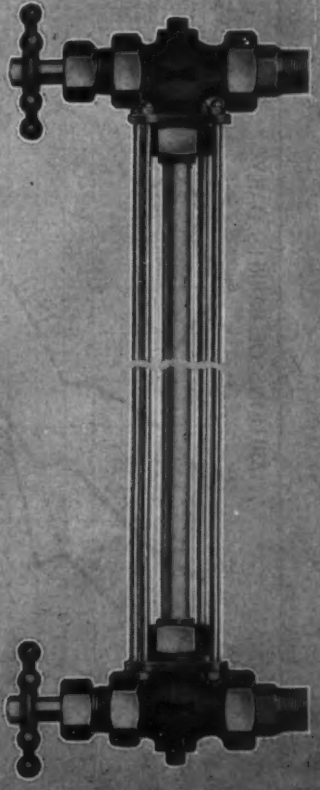
Made of Chromium-molybdenum alloy temperature-resisting steel, extra heavy throughout. Stainless steel trimmed. Tubular glass type gages also available in various other metals suitable for practically all conditions.



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PENBERTHY PRODUCTS

Industry Showing Strain of Heavy Wartime Burden

L. J. LOGAN

CLOSELY interwoven with the nation's vigorous miltary operations and war production, the use of petroleum has expanded ceaselessly until it is far greater than before the war, and even at this advanced stage of the fighting there has not yet occurred any leveling out of demand. Instead, each month has called for more petroleum than the month before, and a further increase in requirements is foreseen for May, the fifth month of this year.

This continued increase of petroleum demand through a large part of the first half of the year, coupled with some hints as to what to expect after V-E Day, makes it appear fairly certain that 1945 is due to be another record-breaking year in use of oils, in spite of any curtailments that may occur temporarily after Germany's defeat. The principal decline to be expected after V-E Day is in military need for gasoline, but that is to be offset by some liberalizing of gasoline rations to U. S. civilians.

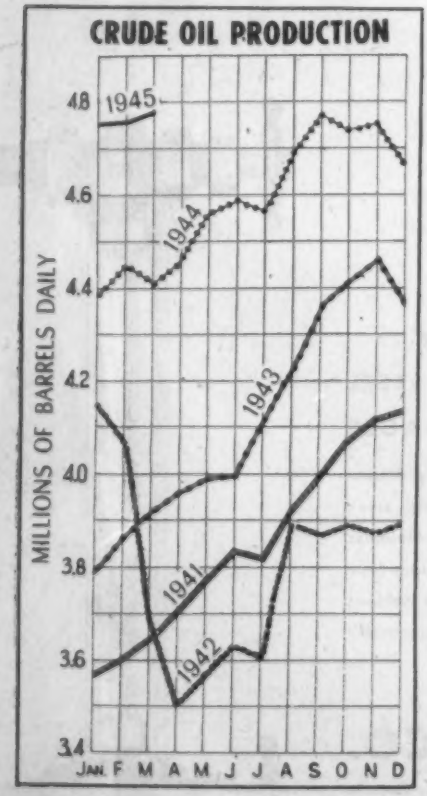
To Use More Oils

Fuel oils will be needed in undiminished volume for intensifying the war against Japan, because of increased operations by sea, and civilians have been warned to expect no loosening up of supplies for their use. This general outlook for coming months, together with the almost half-year of unprecedented petroleum demand already assured, points to substantially greater consumption of oils in 1945 than the record-breaking use of 1944.

The industry has succeeded in keeping abreast of this ever-increasing demand for its products in spite of endless handicaps, which have included shortages and special burdens in many categories. However, it has been necessary to resort to many special and extraordinary measures and to make the most of all existing advantages in order to meet the heavy needs for oils, and from numerous viewpoints the industry now shows the strain of the heavier and heavier burden imposed by the war.

More and more states and districts have reached and gone beyond the limits of efficient crude producing ability, the more recent having included all districts of Texas and adjacent states, while the latest certifications will also put California in the over-producing class. The excessive drawing on fields and wells has been necessary because drilling and exploration have not been possible upon a scale in line with the sharply increased demand for petroleum.

To supplement current production, there has been an extraordinary using up of crude in storage, and crude stocks diminished in March, 1945, to a new low since World War I times. They still are very close to that 23-year low. It will not be possible henceforth to obtain any substantial part of require-



U. S. Crude Oil Production, March and First Three Months

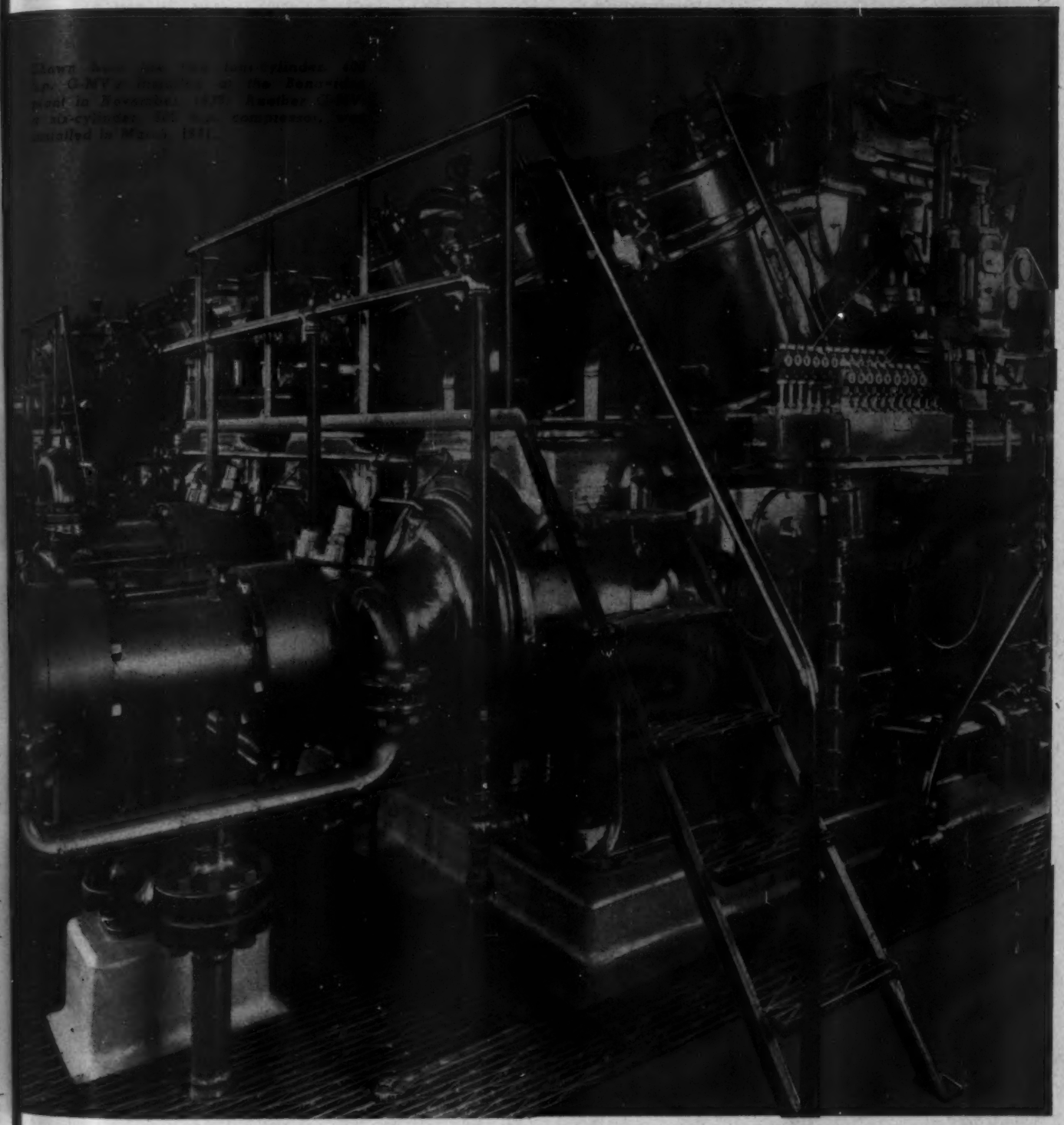
From U. S. Bureau of Mines, except 1945, estimated from A.P.I. weekly reports.

THOUSANDS OF BARRELS

State or District	MONTH TOTAL MARCH				DAILY AVERAGE IN			TOTAL FIRST 3 MONTHS			
	1941	1944	1945	% Diff. '44-'45	1941	1944	1945	1941	1944	1945	% Diff. '44-'45
Alabama			8				.3			24	
Arkansas	2,191	2,490	2,499	+ .4	70.7	80.3	80.6	6,299	7,247	7,313	+ .9
California	18,903	25,667	28,128	+ 9.5	609.8	828.0	907.4	54,941	74,740	80,934	+ 8.3
San Joaquin Val.	7,586	12,013	14,020	+16.7	244.7	387.5	452.3	21,979	35,028	40,247	+14.9
Coastal District	2,558	3,928	4,589	+14.4	82.5	126.7	148.0	7,503	11,320	13,105	+15.8
L. A. Basin	8,759	9,726	9,519	— 2.1	282.6	313.8	307.1	25,459	28,392	27,582	— 2.8
Colorado	125	225	309	+37.7	4.0	7.3	10.0	355	651	876	+37.2
Florida		1				.0			5	3	—40.0
Illinois	10,267	6,704	5,962	—11.1	331.2	216.3	192.3	29,415	19,878	17,928	— 9.8
Indiana	642	450	339	—24.7	20.7	14.5	10.9	1,841	1,289	1,092	—15.3
Kansas	6,258	8,497	8,252	— 2.9	201.9	274.1	266.2	17,968	24,811	23,705	— 4.5
Kentucky	414	720	599	—16.8	13.4	23.2	19.3	1,225	2,078	2,390	+15.0
Louisiana	9,418	10,951	11,342	+ 3.6	303.8	353.2	365.9	26,687	31,938	32,568	+ 2.0
North La.	2,096	2,055	2,179	+ 6.0	67.6	66.3	70.3	6,116	6,071	6,242	+ 2.8
South La.	7,322	8,896	9,163	+ 3.0	236.2	286.9	295.6	20,571	25,867	26,326	+ 1.8
Michigan	1,189	1,597	1,502	— 5.9	38.4	51.5	48.4	3,510	4,794	4,277	—10.8
Mississippi	570	1,267	1,605	+26.7	18.4	40.9	51.8	1,724	3,878	4,539	+16.8
Missouri	4	3			.1	.1		11	9		
Montana	598	741	635	—14.3	19.3	23.9	20.5	1,756	2,185	1,819	—16.7
Nebraska	113	39	29	—25.6	3.6	1.3	.9	337	102	86	—15.7
New Mexico	3,268	3,557	3,220	— 9.5	105.4	114.7	103.9	9,272	10,357	9,322	—10.0
New York	410	399	378	— 5.3	13.2	12.9	12.2	1,206	1,167	1,069	— 8.4
Ohio	273	263	195	—25.9	8.8	8.5	6.3	806	748	566	—24.3
Oklahoma	13,005	10,333	11,469	+11.0	419.5	333.3	370.0	37,711	30,055	32,942	+ 9.6
Pennsylvania	1,336	1,264	1,085	—14.2	43.1	40.8	35.0	3,983	3,615	3,018	—16.5
Tennessee	1	1			.0	.0		3	3		
*Texas	41,030	58,487	66,909	+14.4	1,323.6	1,886.7	2,158.3	116,814	172,980	193,066	+11.6
East Texas Field	11,948	11,362	11,844	+ 4.2	385.4	366.5	382.1	33,280	33,987	34,670	+ 2.0
Rest of E. Texas	2,357	3,615	4,558	+26.1	76.0	116.6	147.0	6,893	10,514	13,085	+24.4
North Texas	4,088	4,416	4,627	+ 4.8	131.9	142.5	149.2	11,750	12,835	13,174	+ 2.6
West Texas	7,365	10,601	14,760	+39.2	237.6	342.0	476.1	20,432	33,296	42,740	+32.3
Tex. Panhandle	2,282	2,895	2,728	— 5.8	73.6	93.4	88.0	6,531	8,554	7,949	—10.2
Gulf C., Upper	7,877	15,932	17,491	+ 9.8	254.1	513.9	564.2	22,301	47,038	50,265	+ 6.9
Gulf C., Lower	3,565	6,063			115.0	195.6		9,776	17,696		
Southwest Texas	2,249	2,353			72.6	75.9		6,331	6,988		
S. Central Texas	642	617			20.7	19.9		1,792	1,810		
S. Texas Total	6,456	9,033	10,901	+20.7	208.3	291.4	351.7	17,899	26,494	31,183	+17.7
Utah								1			
West Virginia	276	270	251	— 7.0	8.9	8.7	8.1	811	782	729	— 6.9
Wyoming	2,357	2,626	3,232	+23.1	76.0	84.7	104.3	7,077	7,907	9,046	+14.4
Total U. S.	112,648	136,552	147,948	+ 8.3	3,633.8	4,404.9	4,772.6	338,753	401,220	427,333	+ 6.5

* Texas data by districts based on A.P.I., and so do not agree exactly with state total, which is on Bureau of Mines basis.

wear in 28,200 hours..

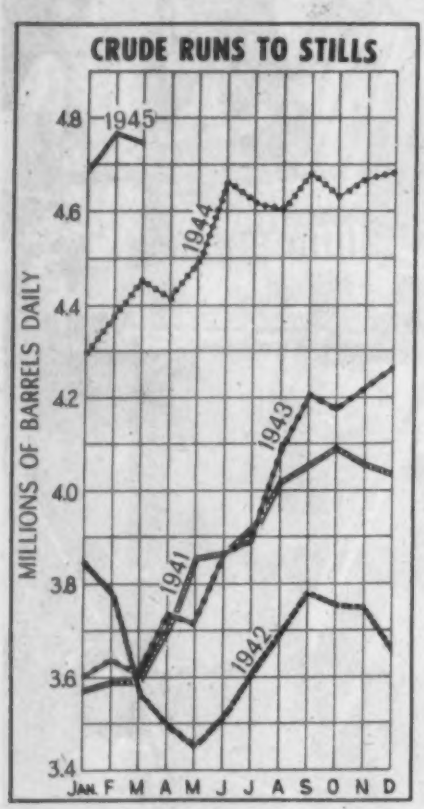


by **Cooper-Bessemer**

MOUNT VERNON, OHIO and GROVE CITY, PENNA.

mand has ceaselessly increased, the inventory in terms of days' supply has become exceptionally small. The March 31, 1945, stocks of all oils represented only 88 days' supply, compared with 99 days' supply held a year before and 140 days' supply on hand March 31, 1941.

It should be pointed out that the drawing on stocks of all oils by nearly 100 million barrels since 1941, in meeting heavy war requirements, was possible only because of prewar surpluses of crude oil and residual fuel oil and because of the streamlining of the industry's operations under the wartime coordination of the industry's activities. Of the 100 million barrels used from storage about one half was residual fuel oil, largely in California, and the remainder was crude oil, with nearly a half of the crude also coming from storage in California.



Stocks of Crude Petroleum in U. S. by Grades, at End of March

(Based on Weekly Reports of U. S. Bureau of Mines)

THOUSANDS OF BARRELS

GRADE OR ORIGIN	March 29 1941	March 28 1942	March 27 1943	April 1 1944	March 31 1945	Change 1941-1945
Pennsylvania Grade	4,291	3,431	2,740	2,465	2,226	−2,065
Other Appalachian	1,400	1,522	1,307	1,396	1,296	−104
Lima-Michigan	1,114	1,549	996	977	954	−160
Illinois-Indiana	21,807	19,337	10,747	14,297	14,421	−7,386
Arkansas	2,888	2,977	2,457	2,768	2,655	−233
Kansas	8,961	7,696	8,372	7,642	9,252	+291
Louisiana	13,897	13,669	13,260	14,033	12,937	+40
Northern	4,342	4,223	4,379	3,701	3,140	−1,202
Gulf Coast	8,555	9,446	8,881	10,332	9,797	+1,242
Mississippi	789	2,445	1,272	786	1,102	+313
New Mexico	7,222	7,510	7,190	6,968	7,105	−117
Oklahoma	64,276	50,513	37,465	32,466	30,448	−33,828
Texas	85,178	96,123	105,391	114,905	112,074	+26,896
East Texas	20,561	23,677	24,659	23,433	19,120	− 1,441
West Texas	15,953	23,961	24,006	29,962	31,917	+15,964
Gulf Coast	23,544	25,889	30,011	34,066	32,173	+8,629
Other Texas	25,120	22,596	26,715	27,444	28,864	+3,744
Panhandle	.....	.....	5,345	6,179	5,434	.....
North	.....	.....	7,365	5,845	7,442	.....
South	.....	.....	4,639	5,538	6,641	.....
Other	.....	.....	9,366	9,882	9,347	.....
Rocky Mountain	15,575	16,628	13,553	9,982	6,453	−9,122
California	37,221	38,454	34,306	24,969	20,301	−16,920
Foreign	2,568	1,354	70	1,013	2,558	−10
Total Gasoline Bearing in U.S.	266,187	263,208	239,126	234,667	223,782	−43,405
Heavy in California	11,963	11,336	10,839	6,507	5,897	−6,066
Total in U. S.	278,150	274,544	249,965	241,174	229,679	−48,471

Lowest Levels

It is evident that storage oils of virtually all classes and all locations have been reduced practically to the lowest levels possible even under coordinated operation of the industry. End of the wars would bring some decline in petroleum consumption temporarily, but return to competitive conditions can be expected to make larger inventories of crude and products desirable.

Similarly, the heavy drawing on underground storage or crude reserves, previously mentioned, will make it essential after the war to increase those reserves, in order to promote greater operating flexibility as well as to assure adequate dependable supply. This means that there will have to be intensified and probably unprecedented drilling in the postwar period and also similarly intensified pre-drilling exploration to line up still more prospects that will have to be drilled before long. Even under this year's increased drilling program of 27,000 new wells there will be completed several thousand wells less than normal, while in 1942, 1943, and 1944 the completions were greatly subnormal. (Completions averaged 30,500 annually in the last 5 prewar years, 1937-1941, but totaled only 21,500 in 1942, 19,000 in 1943, and 24,000 in 1944, while 27,000 are programmed for 1945.)

Besides drawing heavily on both above-ground and underground reserves, in meeting the great wartime demand for oils, there has been a gradual increase in imports of crude and fuel oils in the past couple of years, following the sharp

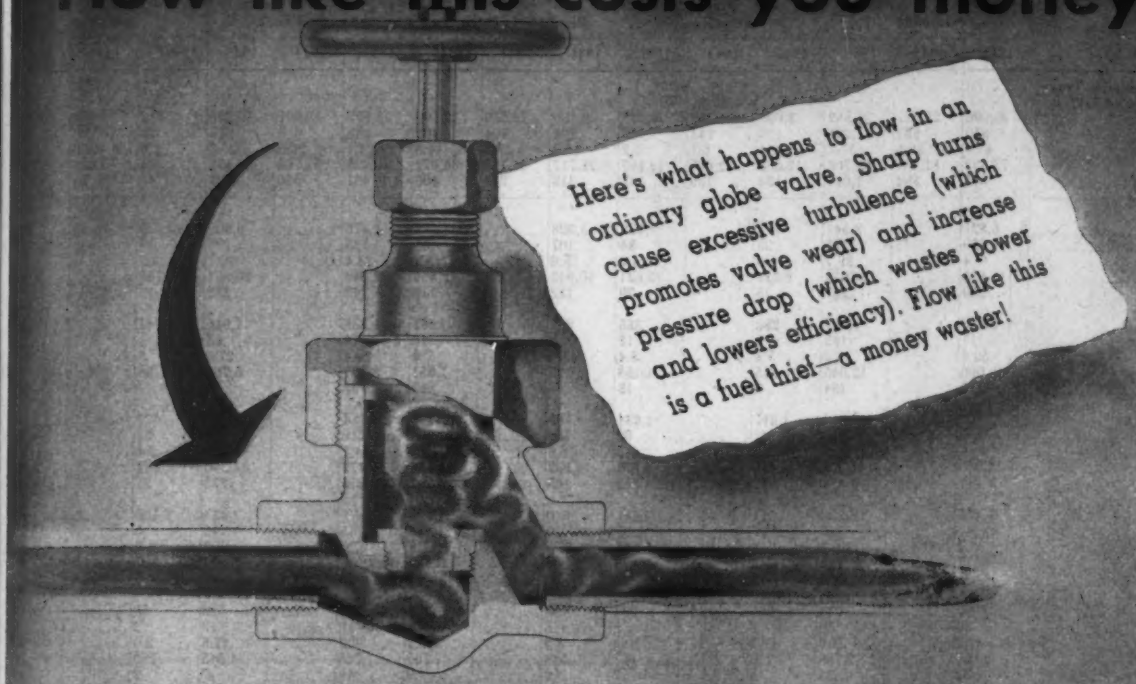
U. S. Crude Runs to Stills and Percent of Refinery Capacity Used by Districts

Runs from Bureau of Mines, except 1945, from American Petroleum Institute; Capacities from American Petroleum Institute.)

THOUSANDS OF BARRELS

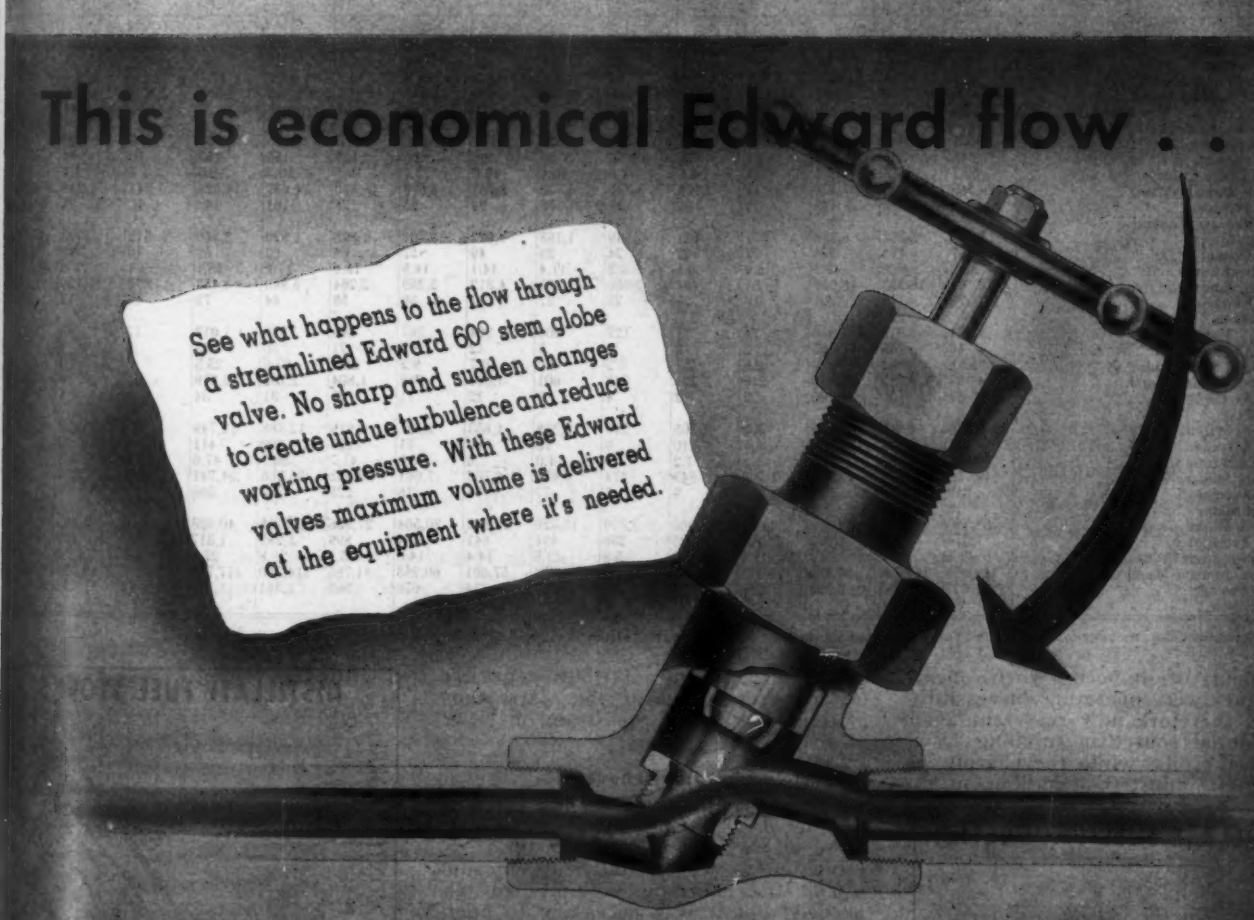
REFINING DISTRICT	CRUDE RUNS IN MARCH: Total Amount Run				CRUDE RUNS IN MARCH: Daily Average Run			REFINING CAPACITY AND USE MARCH: Daily Capacity			REFINING CAPACITY AND USE MARCH: Percent Capacity Used			TOTAL AMOUNT CRUDE RUN TO STILLS FIRST 3 MONTHS			
	March 1941	March 1944	March 1945	% Dif. '44-'45	Mar. 1941	Mar. 1944	Mar. 1945	Mar. 1941	Mar. 1944	Mar. 1945	Mar. 1941	Mar. 1944	Mar. 1945	Jan.-Mar. 1941	Jan.-Mar. 1944	Jan.-Mar. 1945	% Dif. '44-'45
Combined East Coast—Southwest	57,571	71,116	75,559	+ 6.2	1,857	2,294	2,438	2,259	2,483	2,743	82.2	92.4	98.8	167,509	201,017	219,611	+ 9.3
East Coast	17,850	.....	22,541	.....	576	.....	727	643	.....	791	89.6	.....	91.9	50,247	.....	65,456	.....
Inland Texas	5,290	.....	7,082	.....	171	.....	229	280	.....	329	61.1	.....	69.3	15,442	.....	21,072	.....
Texas Gulf Coast	28,164	.....	35,322	.....	908	.....	1,139	1,071	.....	1,237	84.9	.....	92.1	83,309	.....	102,817	.....
Louisiana Gulf Coast	4,000	.....	8,335	.....	129	.....	269	164	.....	260	78.7	.....	103.5	11,933	.....	23,282	.....
North Louisiana and Arkansas	2,267	.....	2,279	.....	73	.....	74	101	.....	126	72.3	.....	58.7	6,578	.....	6,984	.....
Appalachian	4,347	4,679	4,929	+ 5.3	140	151	159	156	177	196	89.7	85.3	81.1	12,691	14,005	14,234	+ 1.6
District No. 1	.....	.....	3,110	.....	.....	.....	100	.....	.....	146	.....	.....	68.5	.....	.....	8,937	.....
District No. 2	.....	.....	1,819	.....	.....	.....	59	.....	.....	50	.....	.....	118.0	.....	.....	5,297	.....
Indiana, Illinois, Kentucky	19,763	23,466	23,914	+ 1.9	638	757	771	743	824	857	85.9	91.9	90.0	56,692	69,280	69,902	+ .9
Oklahoma, Kansas, Missouri	10,214	10,787	11,850	+ 9.9	329	348	382	420	416	469	78.3	83.7	81.4	29,148	31,675	34,529	+ 9.0
Rocky Mountains	2,579	3,399	3,993	+17.5	83	110	129	121	149	172	68.6	73.8	75.0	7,525	9,727	11,034	+13.4
District No. 3	.....	.....	334	.....	.....	.....	11	.....	.....	13	.....	.....	84.6	.....	.....	969	.....
District No. 4	.....	.....	3,659	.....	.....	.....	118	.....	.....	159	.....	.....	74.2	.....	.....	10,065	.....
California	16,585	24,455	26,797	+ 9.6	535	789	864	836	817	955	64.9	96.6	86.6	48,632	72,352	75,918	+ 4.9
Total United States	111,059	137,902	147,042	+ 6.6	3,583	4,449	4,743	4,535	4,866	5,432	79.0	91.4	87.3	322,187	398,056	425,228	+ 6.8

Flow like this costs you money . . .



Here's what happens to flow in an ordinary globe valve. Sharp turns cause excessive turbulence (which promotes valve wear) and increase pressure drop (which wastes power and lowers efficiency). Flow like this is a fuel thief—a money waster!

This is economical Edward flow . . .



See what happens to the flow through a streamlined Edward 60° stem globe valve. No sharp and sudden changes to create undue turbulence and reduce working pressure. With these Edward valves maximum volume is delivered at the equipment where it's needed.

Edward angle type valves have the same characteristics of economical, low pressure drop flow. You save money and increase operating efficiency by making your small globe and angle valves Edward.

EDWARD *Steel* VALVES

The Edward Valve & Manufacturing Co., Inc. • East Chicago, Indiana

Refinery Production of Major Products and Percent Yield from Crude Run, By Districts

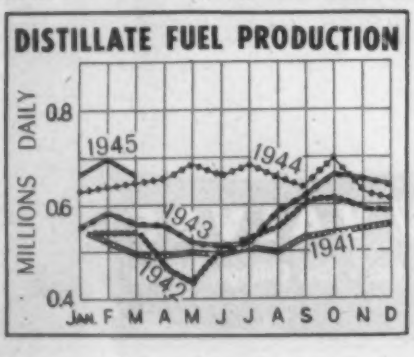
Results in March and first 3 months. Figures for 1941 and 1944 are from Bureau of Mines and for 1945 estimated.

THOUSANDS OF BARRELS

DISTRICTS	*Gasoline			Kerosine			Distillate Fuel Oil			Residual Fuel			Lubricants		
	1941	1944	1945	1941	1944	1945	1941	1944	1945	1941	1944	1945	1941	1944	1945
Combined East Coast, Texas Inland, Texas Gulf, La. Gulf, North La. and Ark.															
Production, March	25,096	28,871	31,882	3,690	4,360	4,738	9,130	12,539	12,690	13,872	18,902	19,298	1,512	1,864	1,906
(Daily Average)	810	931	1,028	119	141	153	294	404	409	448	610	623	49	60	64
Percent Yield from Crude	41.0	36.5	37.7	6.4	6.1	6.3	15.9	17.6	16.8	24.1	26.6	25.5	2.6	2.6	2.6
Production, January-March	73,392	81,401	93,706	12,063	12,665	12,897	28,717	35,186	36,672	40,623	53,768	56,477	4,334	5,289	5,719
(Daily Average)	815	894	1,041	134	139	143	319	237	409	451	590	627	48	58	63
East Coast Only															
Production, March	6,821	.....	8,541	713	.....	1,039	3,328	.....	4,073	4,176	.....	6,909	576	.....	699
(Daily Average)	220	.....	275	23	.....	34	107	.....	131	135	.....	223	19	.....	22
Percent Yield from Crude	37.4	.....	36.7	4.0	.....	4.6	18.6	.....	18.1	23.4	.....	30.7	3.2	.....	3.1
Production, January-March	18,825	.....	24,058	2,228	.....	2,631	10,943	.....	12,466	12,846	.....	20,894	1,758	.....	2,039
(Daily Average)	209	.....	267	25	.....	29	122	.....	139	143	.....	232	19	.....	22
Inland Texas															
Production, March	3,423	.....	4,097	280	.....	385	207	.....	492	1,238	.....	1,945	41	.....	21
(Daily Average)	111	.....	132	9	.....	12	7	.....	16	40	.....	63	1	.....	1
Percent Yield from Crude	52.6	.....	48.2	5.3	.....	5.4	3.9	.....	7.9	23.4	.....	27.5	.8	.....	.3
Production, January-March	10,096	.....	12,045	835	.....	1,155	592	.....	1,551	3,437	.....	5,769	96	.....	61
(Daily Average)	112	.....	134	9	.....	13	6	.....	17	38	.....	64	1	.....	1
Texas Gulf															
Production, March	12,405	.....	14,912	1,917	.....	1,934	4,769	.....	6,397	6,784	.....	8,487	677	.....	954
(Daily Average)	400	.....	481	62	.....	62	154	.....	206	219	.....	274	22	.....	31
Percent Yield from Crude	41.9	.....	36.8	6.8	.....	5.5	16.9	.....	18.1	24.1	.....	24.0	2.4	.....	2.7
Production, January-March	37,033	.....	44,393	6,490	.....	5,575	14,833	.....	18,159	19,472	.....	24,390	1,884	.....	2,684
(Daily Average)	411	.....	493	72	.....	62	165	.....	202	216	.....	271	21	.....	30
Louisiana Gulf															
Production, March	1,455	.....	3,398	514	.....	1,147	640	.....	1,496	1,079	.....	1,437	160	.....	208
(Daily Average)	47	.....	110	17	.....	37	20	.....	48	35	.....	46	5	.....	6
Percent Yield from Crude	35.5	.....	36.3	12.8	.....	13.8	16.0	.....	17.9	27.0	.....	17.2	4.0	.....	2.5
Production, January-March	4,573	.....	10,442	1,740	.....	2,873	1,806	.....	3,821	3,153	.....	3,879	407	.....	601
(Daily Average)	51	.....	116	19	.....	32	20	.....	42	35	.....	43	5	.....	6
North Louisiana and Arkansas															
Production, March	992	.....	934	266	.....	233	186	.....	232	595	.....	520	58	.....	114
(Daily Average)	32	.....	30	8	.....	8	6	.....	8	19	.....	17	2	.....	4
Percent Yield from Crude	42.2	.....	34.0	11.7	.....	10.2	8.2	.....	10.2	26.2	.....	22.8	2.6	.....	3.7
Production, January-March	2,865	.....	2,768	770	.....	663	543	.....	765	1,715	.....	1,545	189	.....	343
(Daily Average)	32	.....	31	9	.....	7	6	.....	9	19	.....	17	2	.....	4
Appalachian															
Production, March	2,026	1,970	2,118	288	349	320	443	530	579	660	779	872	502	441	400
(Daily Average)	65	64	68	9	11	10	14	18	19	21	25	28	16	14	13
Percent Yield from Crude	45.6	41.3	42.3	6.6	7.5	6.5	10.2	11.3	11.2	15.2	16.6	17.7	11.5	9.4	8.1
Production, January-March	5,930	6,074	6,288	865	1,002	933	1,304	1,633	1,641	2,037	2,343	2,563	1,412	1,317	1,143
(Daily Average)	66	67	70	10	11	11	15	18	18	23	26	28	16	14	13
Indiana, Illinois, Kentucky															
Production, March	10,575	11,806	12,712	1,672	1,174	1,116	2,051	3,055	2,909	3,860	4,805	4,752	315	435	407
(Daily Average)	341	381	410	35	38	36	66	98	96	125	155	153	10	14	13
Percent Yield from Crude	50.7	47.3	49.7	5.4	5.0	4.8	10.4	13.0	12.4	19.5	20.5	19.9	1.6	1.9	1.7
Production, January-March	30,589	34,605	37,363	3,113	3,519	3,330	6,120	8,761	8,578	11,545	14,539	14,528	941	1,249	1,165
(Daily Average)	340	380	415	34	39	37	68	96	95	128	161	162	10	14	13
Oklahoma, Kansas, Missouri															
Production, March	5,793	5,362	6,330	701	701	749	1,168	1,522	1,762	1,898	1,926	2,140	312	393	427
(Daily Average)	187	173	204	23	23	24	38	49	57	61	62	69	10	13	14
Percent Yield from Crude	53.0	46.0	49.5	6.9	6.5	6.3	11.4	14.1	14.9	18.6	17.9	18.1	3.1	3.6	3.6
Production, January-March	16,104	16,263	18,059	1,831	2,194	2,059	3,361	4,312	5,289	5,264	5,843	6,453	873	1,128	1,259
(Daily Average)	179	179	201	20	24	23	37	47	59	59	64	72	10	12	14
Rocky Mountains															
Production, March	1,424	1,515	1,940	74	71	127	206	364	367	649	938	1,012	12	33	29
(Daily Average)	46	49	63	2	2	4	7	12	12	21	30	33	.0	1	1
Percent Yield from Crude	52.8	42.5	46.0	2.9	2.1	3.2	8.0	10.7	9.2	25.2	27.6	25.3	5	1.0	.7
Production, January-March	4,193	4,582	5,419	210	221	342	601	1,061	962	1,804	2,792	3,019	51	78	74
(Daily Average)	47	50	60	2	2	4	7	12	11	20	31	34	1	1	1
California															
Production, March	7,036	8,906	9,909	208	305	279	2,328	1,853	2,197	6,919	12,388	12,749	160	322	343
(Daily Average)	227	287	320	7	10	9	75	60	71	223	400	411	5	10	11
Percent Yield from Crude	34.7	31.2	31.1	1.3	1.2	1.0	14.0	7.6	8.2	41.7	50.7	47.6	1.0	1.3	1.3
Production, January-March	19,756	26,831	28,454	500	843	674	6,973	6,708	7,061	20,522	35,365	34,741	667	964	1,067
(Daily Average)	219	295	316	6	9	7	77	74	78	228	389	386	7	11	12
Total United States															
Production, March	51,950	58,430	64,891	6,033	6,960	7,329	15,326	19,863	20,564	27,858	39,738	40,823	2,813	3,488	3,667
(Daily Average)	1,676	1,885	2,093	195	225	236	494	641	664	899	1,282	1,317	90	112	116
Percent Yield from Crude	43.4	38.5	39.7	5.4	5.0	5.0	13.8	14.4	14.0	25.1	28.8	27.8	2.5	2.5	2.5
Production, January-March	149,964	169,756	189,289	18,582	20,444	20,235	47,076	57,661	60,293	81,795	114,750	117,781	8,278	10,025	10,427
(Daily Average)	1,666	1,865	2,103	206	224	225	523	634	670	909	1,261	1,309	92	110	116

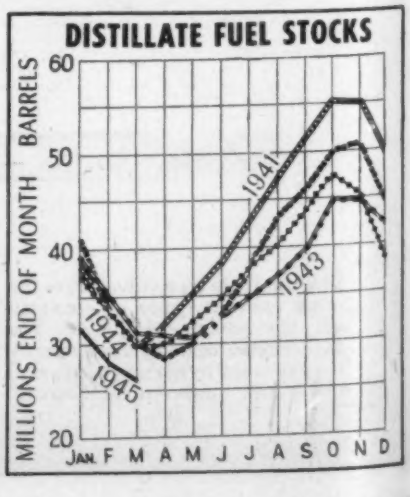
* Production includes straight run, cracked, and natural blended at refineries. Yield indicates percent of crude runs made into straight run and cracked gasoline.

curtailment of imports when enemy submarines were operating successfully. Imports therefore now represent again a substantial source in fulfilling U. S. demand for oils, while the sharply increased oil industry operations in the Caribbean area are contributing greatly toward prosecution of the wars, thus materially relieving the strain on U. S. producers and refiners.



Strain Relieved

For a period in 1944, around the time of the invasion of Western Europe, there was a very great strain on U. S. refineries, as well as oil fields, in supplying the enormous volumes of oils needed, and it was necessary to operate most plants at full capacity over protracted time without pause for normal repairs. It still is necessary to make the fullest practicable use of refining facilities, as requirements for oil products have increased even further. But the strain has been somewhat relieved through completion of additional crude-processing capacity. In March, 1945, refineries of the United States



"what! you mean I can't buy all the Soda Ash I want?"

YES, MR. INDUSTRIALIST, that's the situation on Soda Ash . . . as long as present heavy war demand continues.

Too often this basic "work-horse" of industry is taken for granted. Yet Soda Ash is absolutely indispensable in a wide variety of industrial processes.

What has happened to all the Soda Ash? It has gone into vastly expanded production of glass containers to save scarce metals. Into the manufacture of aluminum and other metals vital to war production. Into the making of explosives. Into the manufacture of chemicals, pulp and paper, textiles, soap and soap powders, water softeners, cleansers and literally hundreds of miscellaneous materials.

Despite war's complications, alkali manufacturers have set an enviable record in supplying the steadily expanding Soda Ash requirements of industry. And Mathieson, playing no favorites, has followed a policy in its commitments of "cutting the cloth to fit the pattern", is continuing to take care of its contract customers, large and small, with little or no occasion for late deliveries or other disappointments . . . regrets only that its production facilities have not been great enough at all times to serve all potential Mathieson customers.

Yes, Mr. Industrialist, if they ever start pinning medals on industrial products for valiant war service, Soda Ash will sport a chest full! Think of that if you haven't been able to buy all the Soda Ash you want!

Mathieson
CHEMICALS

THE MATHIESON ALKALI WORKS (INC.)
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Soda Ash... Caustic Soda... Liquid Chlorine... Bicarbonate of Soda... Chlorine Dioxide... Ammonia, Anhydrous & Aqua ...HTH Products... Fused Alkali Products... Synthetic Salt Cake... Dry Ice... Carbonic Gas... Sodium Chlorite Products... Sodium Methylate

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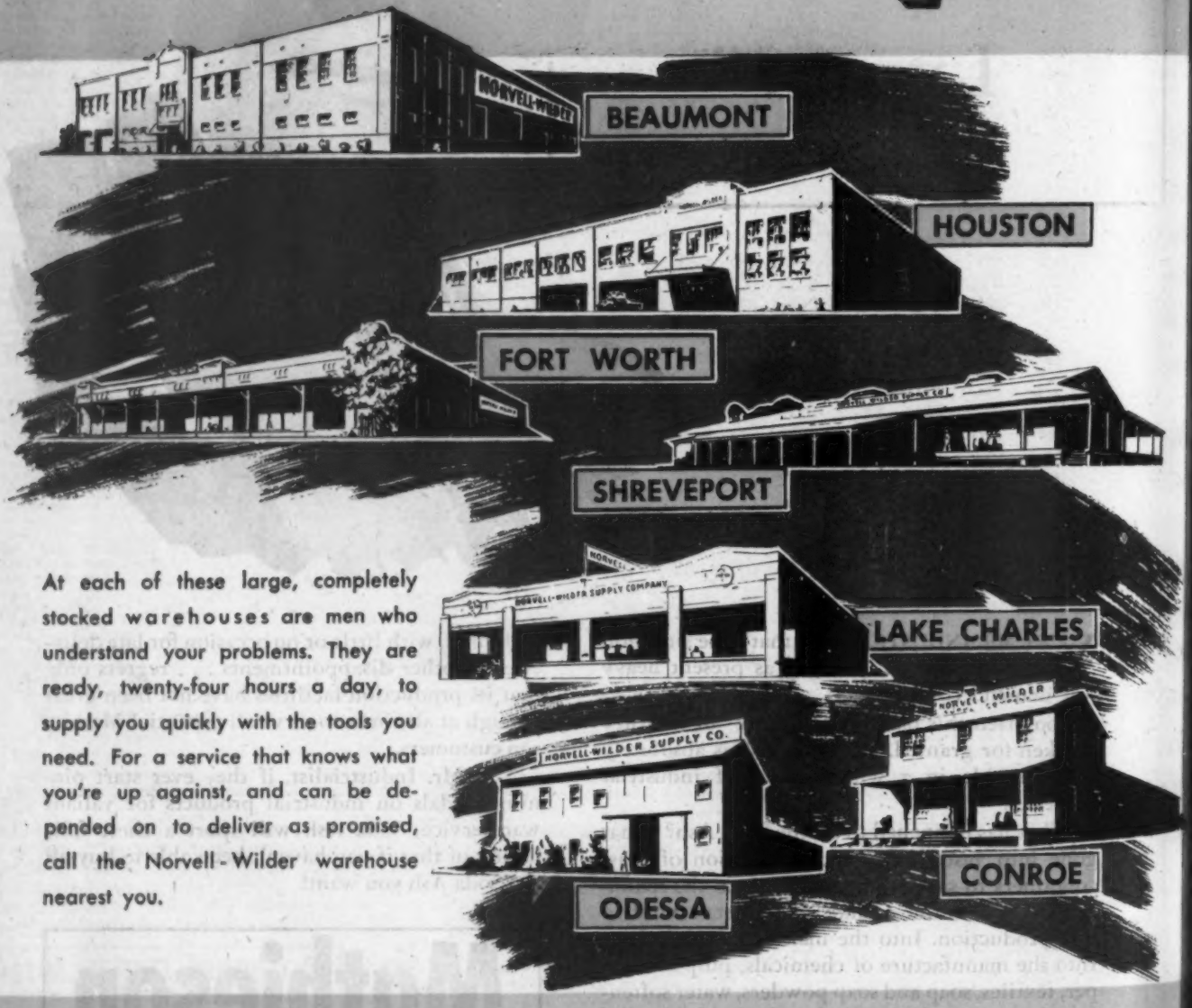
Service you



At each of these large, completely stocked warehouses are men who understand your problems. They are ready, twenty-four hours a day, to supply you quickly with the tools you need. For a service that knows what you're up against, and can be depended on to deliver as promised, call the Norvell-Wilder warehouse nearest you.

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DELIVERY . . . NIGHT AND DAY . . . . .

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When you need oil field supplies, you want to deal with men who know the problems in your area; who have the experience and the lines of equipment to give you the things you need; who will get them in your hands quickly.

For thirty-five years we have specialized in oil field equipment in the Mid-Continent and Gulf Coast fields. We realize that there is no business on earth where service means more than in the oil field. The proved, nationally-known lines that we carry, and the reliable service we offer are your assurance that when you call the Norvell-Wilder man, you'll get the right tool at the right time. Call us, for better selection and quick delivery.

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Babcock and Wilcox	Still Condenser Tubes
A. M. Byers Company	Wrought Iron Pipe
Chaplin Fulton Company	Regulators
Dean Brothers Pumps, Inc.	Pumps
Hewitt Rubber Corp.	Packing, Hose
Hughes Tool Company	Valves
Kennedy Valve Mfg. Co.	Valves, Fittings
Ladish Drop Forge Company	Flanges, Forgings
A. Leschen & Sons Rope Company	Wire Rope
The Lunkenheimer Company	Valves, Steam Specialties
Merco Nordstrom Valve Company	Plug Valves
Pittsburgh Steel Company	Stainless Tubes, Still Tubes, Carbon Moly Pipe
Quigley Company	Refractories, Insulation Material
Reed Roller Bit Company	Valves
Republic Steel Company	Line Pipe, Condenser Tubes
Strong, Carlisle & Hammond	Traps
Tube Turns, Inc.	Tube Turns, Flanges
Watson Stillman Company	Forged Steel Fittings
Victualic Company of America	Couplings

SA-1

L WILDER

COMPANY

operated at 87 percent of capacity in charging to stills an average of 4,743,000 barrels of crude per day. In March of last year the existing capacity was utilized 91 percent in charging to still 4,449,000 barrels of crude per day. The country's plants at present have a record high capacity of 5,432,000 barrels per day, up more than 500,000 barrels since a year ago and up more than 1,000,000 barrels since this time of 1941. California refineries operated at 87 percent of capacity in March, but the scheduled increase in crude production for the state in May will result in near-capacity operation of the California refineries, heretofore not necessary. East Coast and Texas Gulf Coast plants operated at 92 percent of rated capacity in March, and Louisiana Gulf Coast plants at full capacity, while Illinois-Indiana-Kentucky plants utilized capacity 90 percent. Other interior plants showed lower percentages of capacity used, due in part to lack of sufficient crude or to transportation difficulties. Oklahoma-Kansas-Missouri plants used 81 percent of capacity in March and those of the Rocky Mountains 75 percent.

Demand for Oils Great

Figures presented in accompanying tables show that this year is bringing an increase in oil consumption similar to gains in normal peacetime years, and also that the average gain per year since Pearl Harbor has been about normal, with the sharply expanded military use more than offsetting curtailments of civilian consumption. The industry's operations therefore are currently in general about one third above those of 1941.

In the first quarter of 1945 the total demand for all oils was 8 percent greater than in the like period of 1944 and 33 percent greater than in 1941, not considering imports in either year. Domestic production of crude oil likewise is up in approximately these same ratios, while increases for natural gasoline production are 16 percent over last year and 48 percent over 1941. Similar increases are indicated for the month of March, compared with 1944 and 1941. Crude runs to stills also show similar increases, those in the first three months of 1945 having been 7 percent higher than in 1944 and 32 percent greater than in 1941.

Especially responsible for the large increases in total demand for petroleum has been residual fuel oil. Demand for that product in the first three months of this year was 11 percent larger than last year and 52 percent greater than in the corresponding months of 1941, disregarding imports in all years. Domestic production of residual fuel in the first quarter of 1945 was 2.6 percent larger than in the similar period of 1944 and 44 percent higher than in 1941.

Distillate fuel oil has shown substantial increases in consumption, too, although rationing of supplies to civilians has been a limiting factor. Indicated demand for the first quarter was 3 percent higher in 1945 than 1944 and 19 percent higher than in 1941, not considering imports. The domestic production off this product in the first quarter was nearly 5 percent above last year and 28 percent above 1941.

Increases in demand for kerosine have been similar to those for distillate fuel oil, the first quarter having shown a gain of 4 percent over 1944 and 13 percent over 1941.

More Gasoline Used

Although the use of gasoline was under prewar in the years immediately after Pearl Harbor, because of rationing, it subsequently has increased in response to heavy military needs, and in the first quarter of 1945 was 10 percent higher than in the like period of 1944 and 29 percent higher than in 1941. Since very small amounts of gasoline are imported at any time, domestic production has shown increases about the same as those in demand.

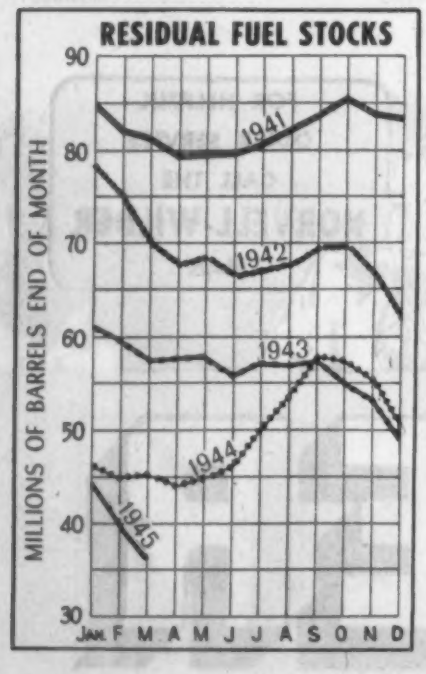
The heavy demand for residual fuel oil has necessitated adjustment of refining operations to afford relatively high yields of that product. The yield in March, 1945, was 27.8 percent, which was down from 28.8 percent in March last year but still materially above the 25.1 percent for March, 1941. Yield of distillate fuel oil also was lower than a year ago but still above 1941. Conversely, there was after Pearl Harbor a reduction in yield of gasoline as demand for that product diminished, but the yield now is being adjusted gradually back up. In March, 1945, it was 39.7 percent against 38.5 percent in March, 1944, and 43.4 percent in March, 1941.

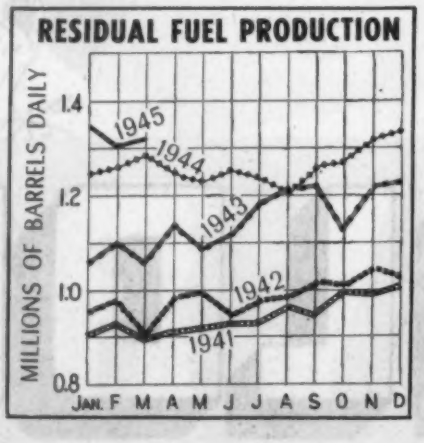
Stocks of Major Petroleum Products Held by Refining Companies in the United States at End of March, 1941, 1944 and 1945

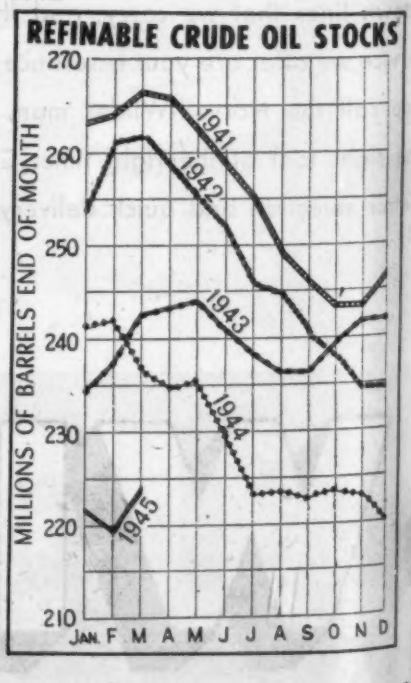
(Stocks at refineries, at bulk terminals, in transit, and in pipe lines. Data for 1941 and 1944 from Bureau of Mines monthly reports; for 1945 from weekly reports of American Petroleum Institute.)

THOUSANDS OF BARRELS

DISTRICT	FINISHED AND UNFINISHED GASOLINE Stocks End of March			KEROSINE Stocks End of March			GASOIL AND DISTILLATE FUEL Stocks End of March			RESIDUAL FUEL OIL Stocks End of March		
	1941	1944	1945	1941	1944	1945	1941	1944	1945	1941	1944	1945
Combined East Coast—Southwest	45,673	36,777	41,386	4,236	4,100	4,507	15,836	14,277	13,325	20,111	16,117	13,666
East Coast	21,113	.....	13,781	1,146	.....	2,174	7,998	.....	5,093	8,371	.....	5,498
Inland Texas	2,965	.....	3,029	141	.....	153	188	.....	297	1,501	.....	639
Texas Gulf Coast	17,061	.....	16,701	2,190	.....	995	6,291	.....	5,213	7,376	.....	5,731
Louisiana Gulf Coast	3,681	.....	5,116	556	.....	884	1,119	.....	1,966	2,303	.....	1,539
North La. and Arkansas	853	.....	2,759	203	.....	301	240	.....	756	460	.....	360
Appalachian	3,628	3,394	3,838	139	248	271	350	1,293	494	521	366	302
District No. 1	.....	.....	2,422	.....	.....	238	.....	.....	377	.....	.....	340
District No. 2	.....	.....	1,416	.....	.....	33	.....	.....	117	.....	.....	152
Indiana, Illinois, Kentucky	20,782	20,739	24,086	806	1,279	1,342	2,397	4,703	3,413	2,801	2,784	1,773
Oklahoma, Kansas, Missouri	9,230	8,309	9,604	453	369	459	1,034	1,588	1,670	2,016	1,293	1,234
Rocky Mountains	2,493	2,457	2,613	119	86	139	332	370	370	565	617	663
District No. 3	.....	.....	83	.....	.....	15	.....	.....	15	.....	.....	30
District No. 4	.....	.....	2,530	.....	.....	124	.....	.....	355	.....	.....	633
California	17,116	15,424	17,185	971	485	409	10,060	7,695	7,617	56,885	24,250	18,131
Total United States	98,922	87,100	98,712	6,724	6,567	7,127	30,009	29,926	26,889	82,899	45,427	35,948







Pictures Aid Personnel Training

LYNE S. METCALFE

EVEN prior to the present war, the oil industry stood at the forefront in the practical use of motion pictures and slide films in the training of personnel, in advertising, in promotion, and in public-relations activities. However, these programs largely were confined to the larger distributors and merchandisers of petroleum. Even the largest refiners had not, on any great scale, brought the picture screen medium into the field of refinery personnel education, though some headway had been made in that direction.

The pre-war experience of the petroleum industry with films as a means of communicating ideas and information, undoubtedly proved to be of great value in the war effort seeing that there is almost no government, industrial, or armed forces operation which does not use slide films or motion pictures in one form or another, for one purpose or another. It has been said that as much as 40 percent of all time otherwise spent in wartime training has been saved by the integration of visuals with other forms and mediums of teaching.

Of course, it is not implied here that films are not at present doing a job for the industry. The point is that much that has been learned about their more efficient and effectual use during the war will be made available to the industry after the war, as it is being done now on a limited scale.

In the first place, wartime experience has confirmed the opinion held in the industry prior to the war that the various educational and training services performed by the picture screen are effective according to success in (a) selecting the proper type of film for the particular job, (b) *using* the film as a teaching medium instead of merely *showing* it, and (c) looking upon it chiefly as a powerful *supplementary* teaching medium—supplementary to other forms and methods of instruction.

The primary objectives of the use of films in wartime training may be quickly summed up, and in each of them the oil industry has an interest:

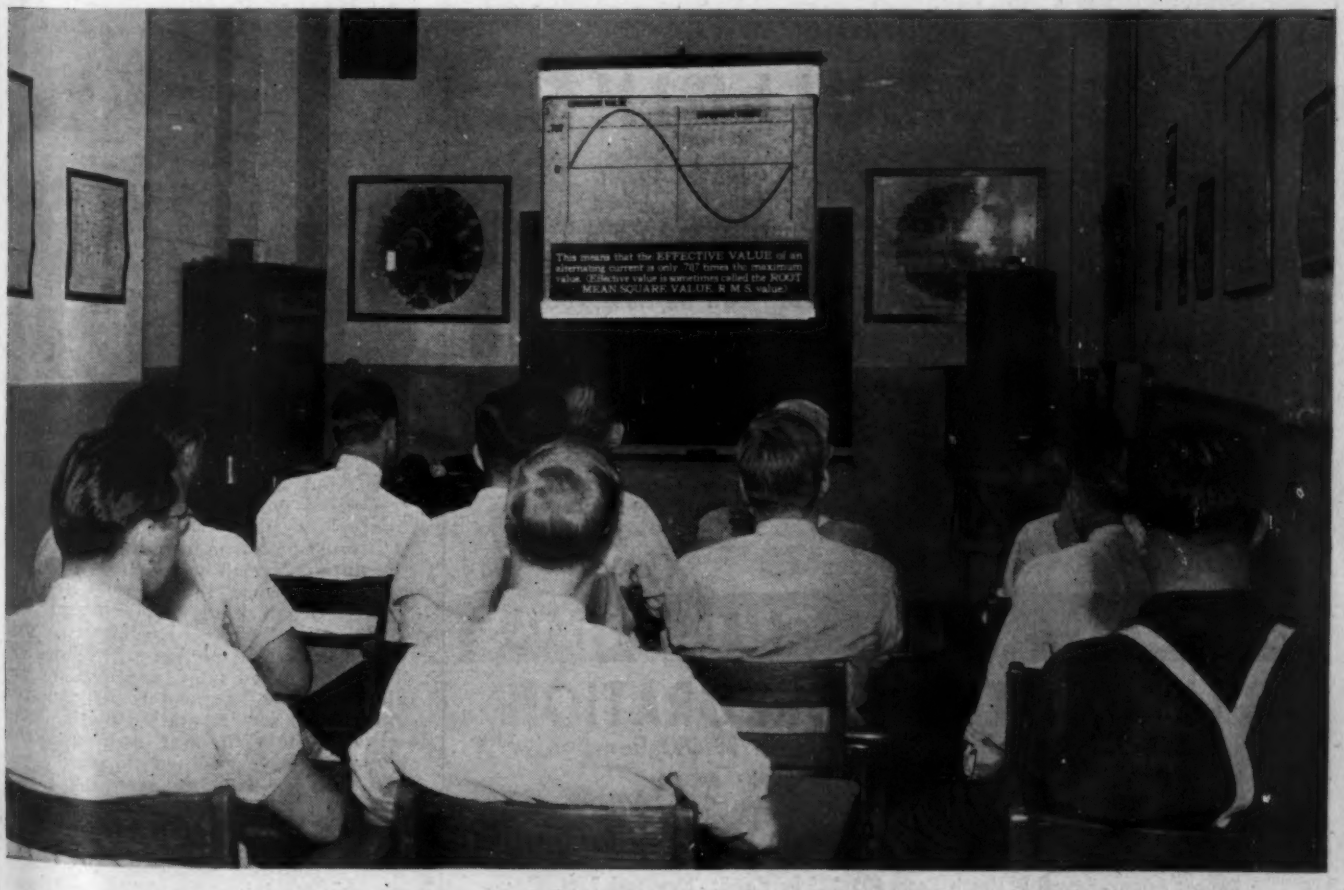
1. Information transference—such as showing convincingly the scope, material sources, processing of the industry.
2. To help teaching special skills in refining and processing.
3. Mechanical instruction—the how-it-works how-to-work-it type of instruction.
4. Morale or employe relations (largely movies).

There are, of course, numerous subdivisions of these primary objectives for which films of one kind or another have been and are being effectively enlisted.

The industry has at its disposal certain types of films each of which has proved to be most economical and effectual for a given type of teaching or communication. There is, for instance, the silent motion picture which is useful for making broad general impressions of properties for which no great amount of oral or printed explanation is necessary. Example: to depict the extent, equipment, and activity of an oil property. We have the motion picture with sound which provides a touch of drama and human interest and has an inspirational effect. Example: a picture to enthuse and build up employe pride in company and policies. There is the "discussional" type slide film—a strip of 35 mm safety motion-picture film on each segment or frame of which is a picture—with letterings, labels, legends superimposed on the film and projected on picture screen or wall with the visuals to augment and clarify what is shown. This type is best for pre-teaching in mechanical and workshop studies. Example: to show the beginner the purpose, simpler techniques, tools and equipment of a given job in advance of workshop field, or location demonstration or confrontation with the actual job itself. There is the sound slide film, which is also a strip of motion picture film each frame a picture, but with a minimum of letterings superimposed, the augmentation of the visualized information being supplied by voice or voices on disc record, synchronized with the film. Example: where it is desired to have a running oral commentary without the necessity of a speaker in person or where a professional voice is preferable.

There are other variations and combinations of these visuals, but these are the basic forms which the oil industry will find most useful from now on.

There are certain advantages, as pre-



Pictures insure greater concentration by the audience

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Braden Sectional Steel Buildings are particularly suited to the installation of the fine interior finishes often desired in offices, laboratories, drafting rooms, etc.

Insulation, walls, ceiling and lighting can be as elaborate as necessary or desired, and more easily installed than on wood or masonry construction.

***Photo above:* A 14' x 36' x 10' Braden Sectional Steel Building with Personnel and Plant Superintendents offices. Ceilings and walls have 4" insulation, Composition block ceiling, wall board and stained pine paneled walls, and concrete floors with inlaid tile linoleum.**

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viously intimated, in each of these film forms.

Discussional slide films are most flexible in the program of the instructor. Any frame can be held on the screen for elaboration and discussion. It is possible to turn back to any previously seen picture or sequence, and it can be projected as refresher material by an individual apprentice. They provide the instructor with a well-laid-out lesson plan and lesson material. Usually these films are integrated with the personnel-training lesson in this way:

Introduction of the subject by the instructor or leader—with discussion; projection of the film as the leader reads off the captions aloud; general discussion of what has been learned; re-showing of the film with prearranged pauses for detailed explanation and discussion; question and answer period, and summation by the instructor or leader, followed by workshop or property demonstration and/or work projects.

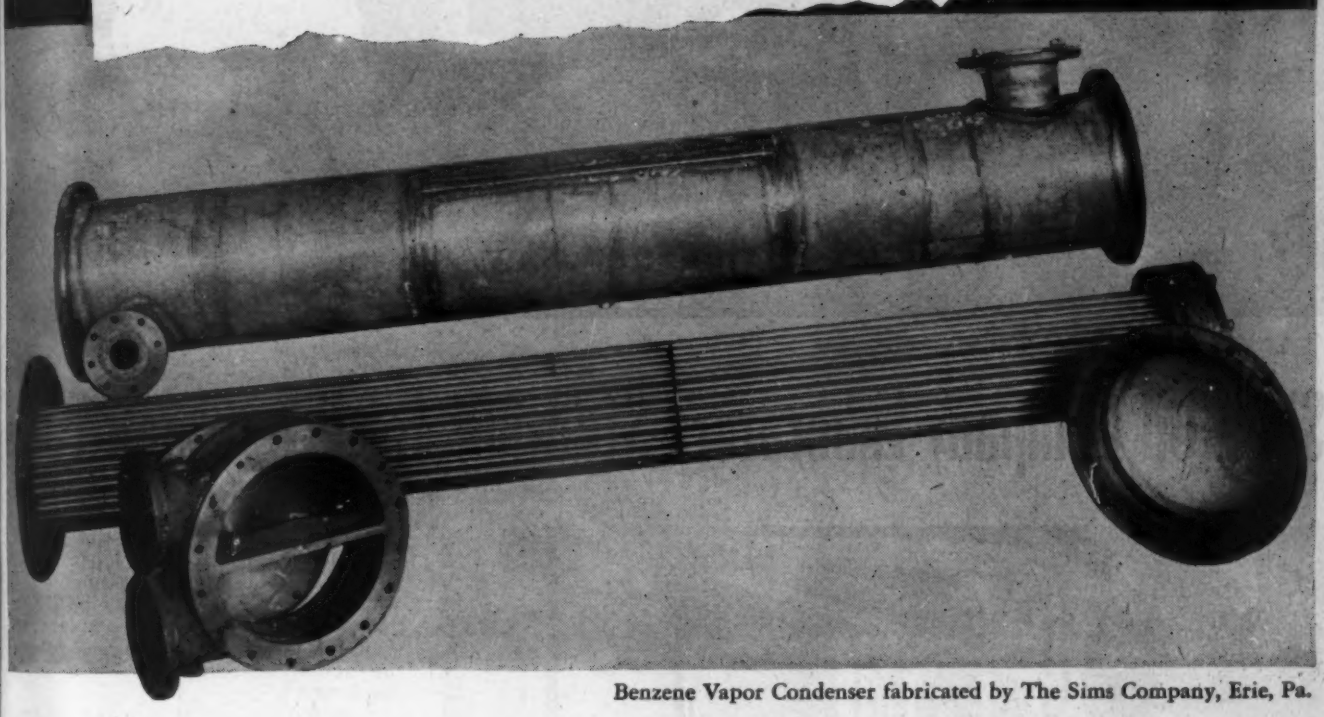
Motion picture scenes cannot be successfully held for discussion. However, they do, especially when with sound, make possible showings of mechanical actions otherwise unseeable by the eye, by means of animated cross-section drawings, show things in motion where motion is a factor in the thing being explained, more surely hold attention because of the effect of motion itself, slowdown or speedup actions for special study, provide well studied and rehearsed commentary and dialog (on the film) and which will always be spoken the same with no variation in oral quality as usually happens when many speakers do the commentary in person at many points and before many groups.

Upon these broad, basic principles the industry will select the types of visuals best suited to the job in hand, and it is likely that we will find production and refining processes benefiting by the use of this rapidly developing medium as sales and merchandising have in the past.

The fact is that the oil refinery of today—and tomorrow—will be faced with a more or less continuous personnel training program. To some extent at least, much new help has drifted into the industry, some of it totally untrained, a result of war conditions, and much new help will have to be trained in future. Many refinery men of experience serving abroad in the armed forces will need a certain amount of training in view of changes and improvements of processes and equipment during the war. That this program can be stepped up and made more economical and efficient when films of various types are properly integrated with textbook, manual, classroom and workshop teaching is a certainty.

It must be borne in mind that, next to the automotive industry, the leading oil companies were the largest users of visuals of all kinds prior to the war. Distributive sales organizations used dealer education pictures, branches and dealerships used sales training films, and films designed to speed up instruction in garage and service station methods and services. Since the war, scores of other industries have adopted the medium to more quickly prepare green help for the first contact with machinery, tools and raw materials. Nowadays, after a pictorial explanation of the job, its objectives, tools and materials, the worker goes on the job at least "knowing what it is all about."

Anaconda Metals FOR BENZENE VAPOR CONDENSER IN BUTADIENE PLANT



Benzene Vapor Condenser fabricated by The Sims Company, Erie, Pa.

THE CONDENSER shown above was fabricated by The Sims Company, Erie, Pa. for one of the world's largest rubber companies to speed production of synthetic rubber.

The Everdur* shell is 17½ inches in diameter and the overall length of the unit is 139½ inches. Anaconda Copper Tubes are used in the bundle. Baffles are of Everdur and heads of cast gun metal. The shell is formed by carbon-arc welding with Everdur Rod.

Materials for this vital equipment must withstand variable corrosive conditions, and the selection of Anaconda Metals was prompted by years of experience with Anaconda Copper and Copper Alloys. For detailed information on alloys suitable for heat transfer or condenser equipment, write for Publication B-2. 44188

*Reg. U. S. Pat. Off.

THE AMERICAN BRASS COMPANY

Subsidiary of Anaconda Copper Mining Company

General Offices: Waterbury 88, Connecticut

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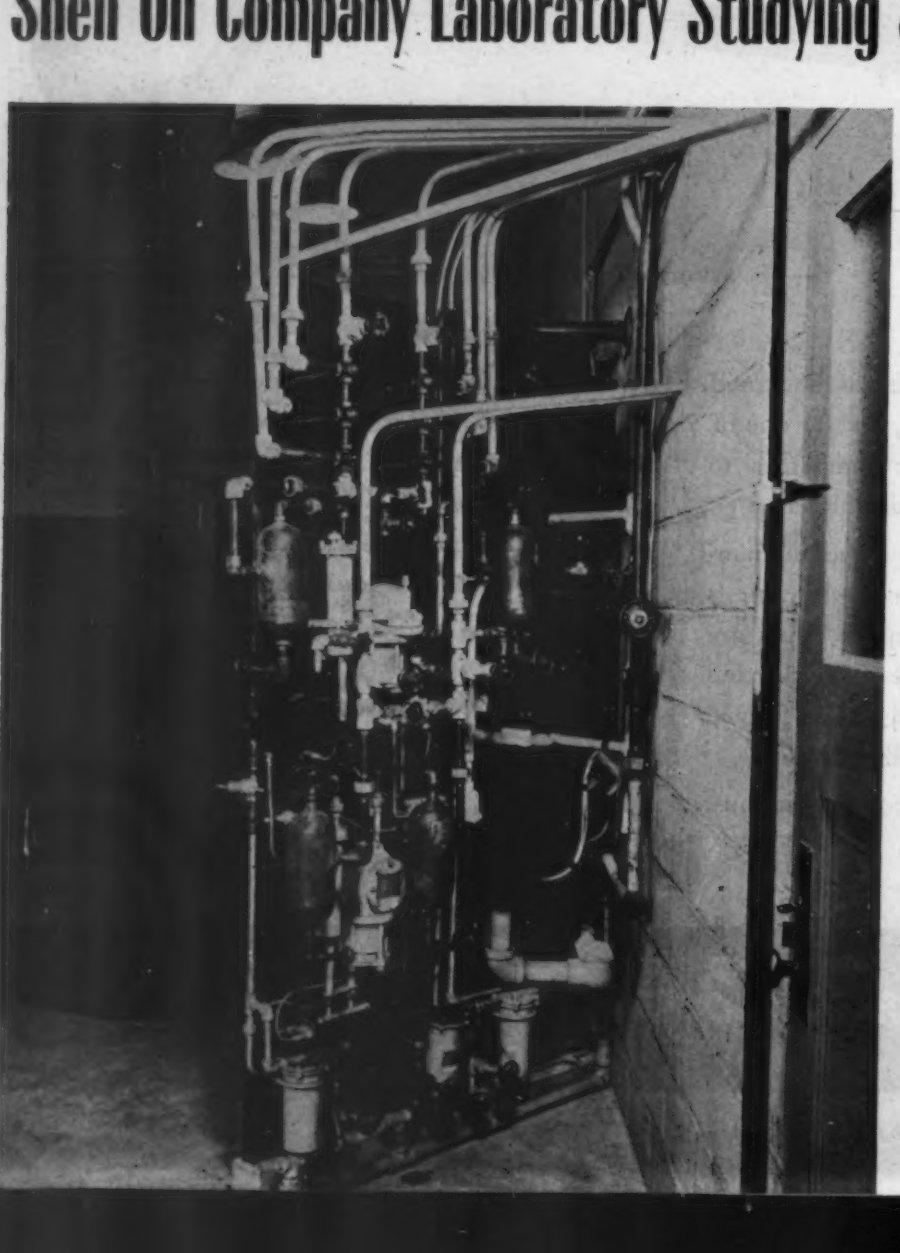
ANACONDA from mine to consumer *Anaconda Copper & Copper Alloys*

Shell Oil Company Laboratory Studying Jet-Propulsion Fuels



A LABORATORY for the study of fuels and lubricants for jet-propulsion aircraft has been put into operation at Wood River, Illinois, by Shell Oil Company. The laboratory, a complete, full-scale installation, was designed to study the action that fuels undergo in jet-combustion.

A jet burner, whose size and construction remain a military secret, has been installed; fuel is furnished by ten 5000-gallon tanks; and compressed air, necessary for jet-combustion, is supplied by a 1000-horsepower compressor. The jet burner produces in a much smaller space about 250 times the heat of a residential oil burner; creates a stream of hot gas of greater than hurricane velocity.

Combustion of such a radically new character requires new basic research, and completely new studies of burning characteristics of possible fuels have been undertaken. By means of elaborate electrical recording devices located in a sound proofed control room, the new laboratory is compiling performance records on fuels suitable for use in jet-propulsion and combustion turbine engines.

In addition to surveying fuel require-

At top is the control board responsible for recording experimental data as well as automatically operating the jet burner in Shell Oil Company's new jet-propulsion laboratory at Wood River, Illinois. It is in a heavily insulated and sound-proof room. The engineer at center sits in front of an observation window through which he can watch the burning of the fuel. At the left is a view of the back of one wing of the board, showing an elaborate maze of gauges and automatic regulators.

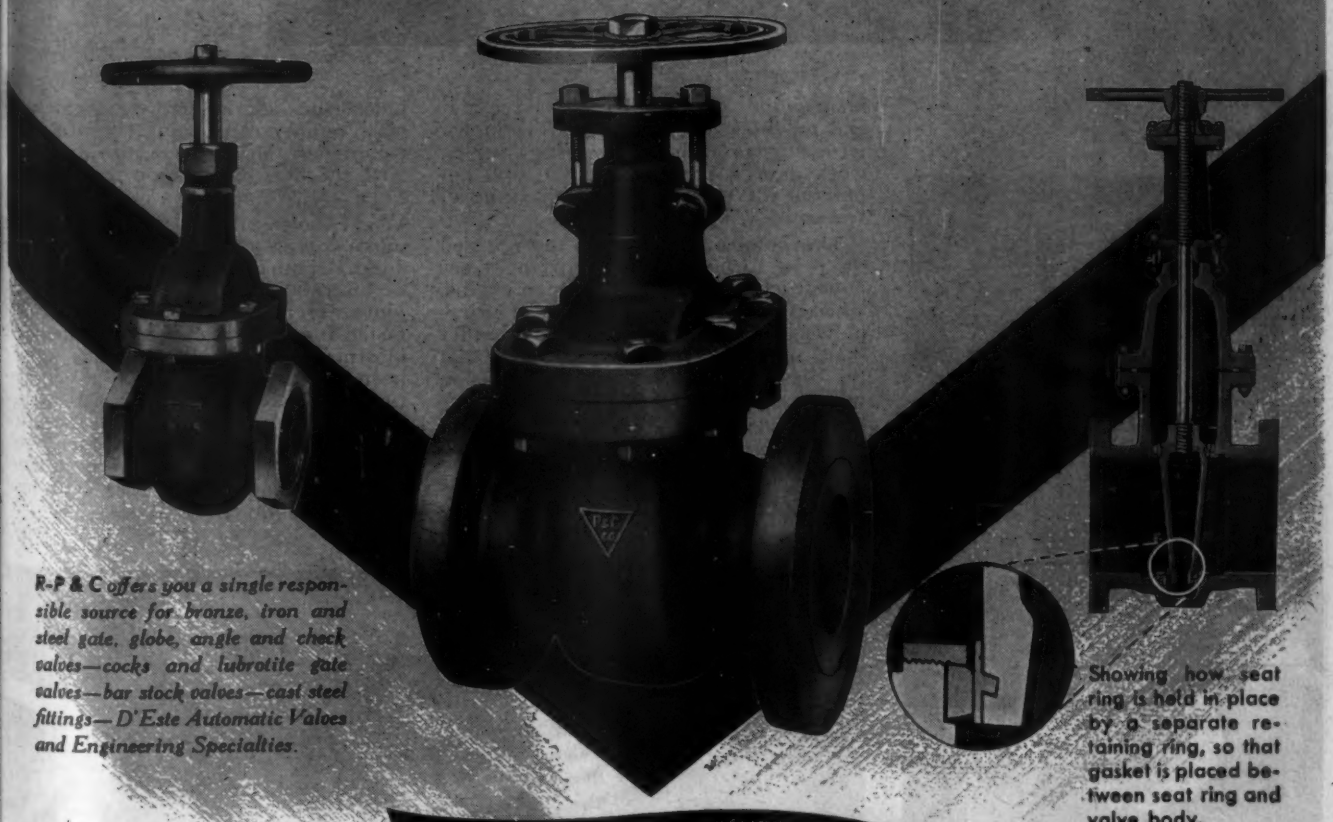
BETTER AND LONGER *Service* FROM *Gate* VALVES...

The retaining ring construction permits easy renewal of seats—with assurance of a good, tight job. This means a definite economy—especially in the larger size valves. But that is only part of the story.

The resilience afforded by the gasket between ring and body results in a more positive seal—better valve performance.

This retaining ring construction is exclusively a **READING-PRATT & CADY** development. It is typical of improvements in valve design constantly being made by **R-P&C** engineers, toward better valve performance and longer valve life.

Next time you have need for valves, get a recommendation from **READING-PRATT & CADY.**



R-P & C offers you a single responsible source for bronze, iron and steel gate, globe, angle and check valves—cocks and lubrotite gate valves—bar stock valves—cast steel fittings—D'Este Automatic Valves and Engineering Specialties.

Showing how seat ring is held in place by a separate retaining ring, so that gasket is placed between seat ring and valve body.

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READING-PRATT & CADY DIVISION
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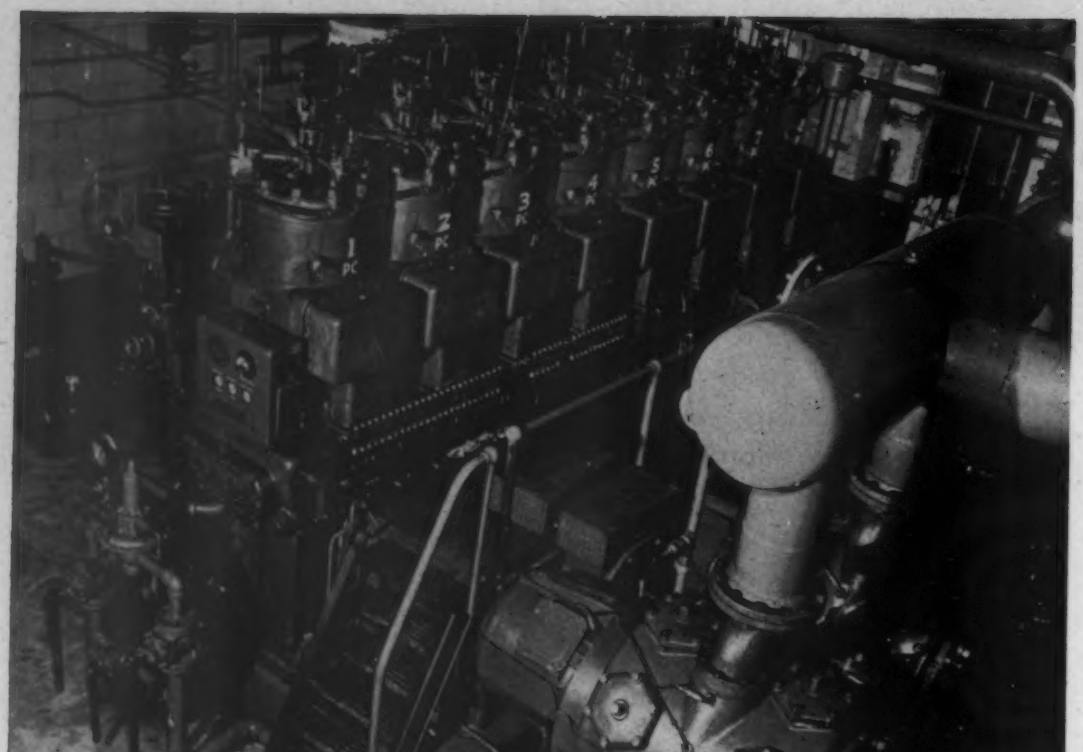
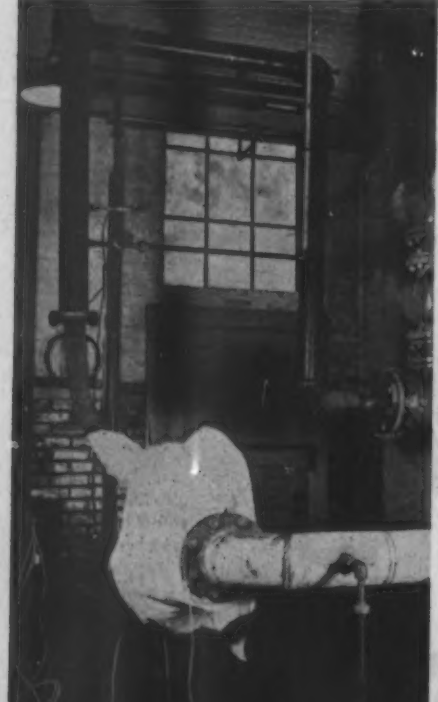


Compressor installation which supplies compressed air used by the jet burner under test by Shell Oil Company at Wood River, Illinois.

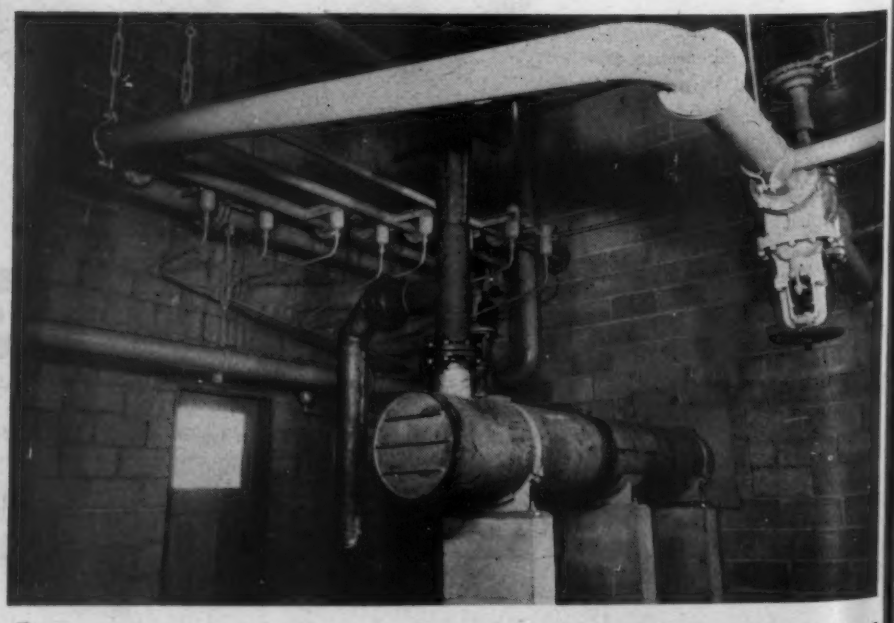
ments, and determining characteristics and qualities of fuels most efficient for jet-combustion, the laboratory is also at work developing new experimental apparatus for further use in this type of research.

The combustion turbine (also called the gas turbine), an important component part of the jet-propulsion engine, appears to have possibility as a prime mover engineers feel. In aircraft other than military craft they believe that the best application of jet-propulsion will be in combination with a combustion turbine-driven propeller. Dream of engine designers for over a generation, the combustion turbine has only recently become a reality through developments in metallurgy which made possible turbine blades able to withstand extremely high temperatures, and centrifugal air compressors efficient enough to be used with the new combustion turbine.

The engine-testing section of the Wood River laboratories is one of the most complete of its kind, containing dozens of miniature and full-scale models of aircraft, automotive, and diesel engines. Here fuels and lubricants are tested for performance, and some of the information thus obtained has already been directly responsible for contributions to the technology of aviation gasoline manufacture during the past few years. Since 1942, enemy fuels, both German and Japanese, have been tested and broken down into their component parts for complete analysis.

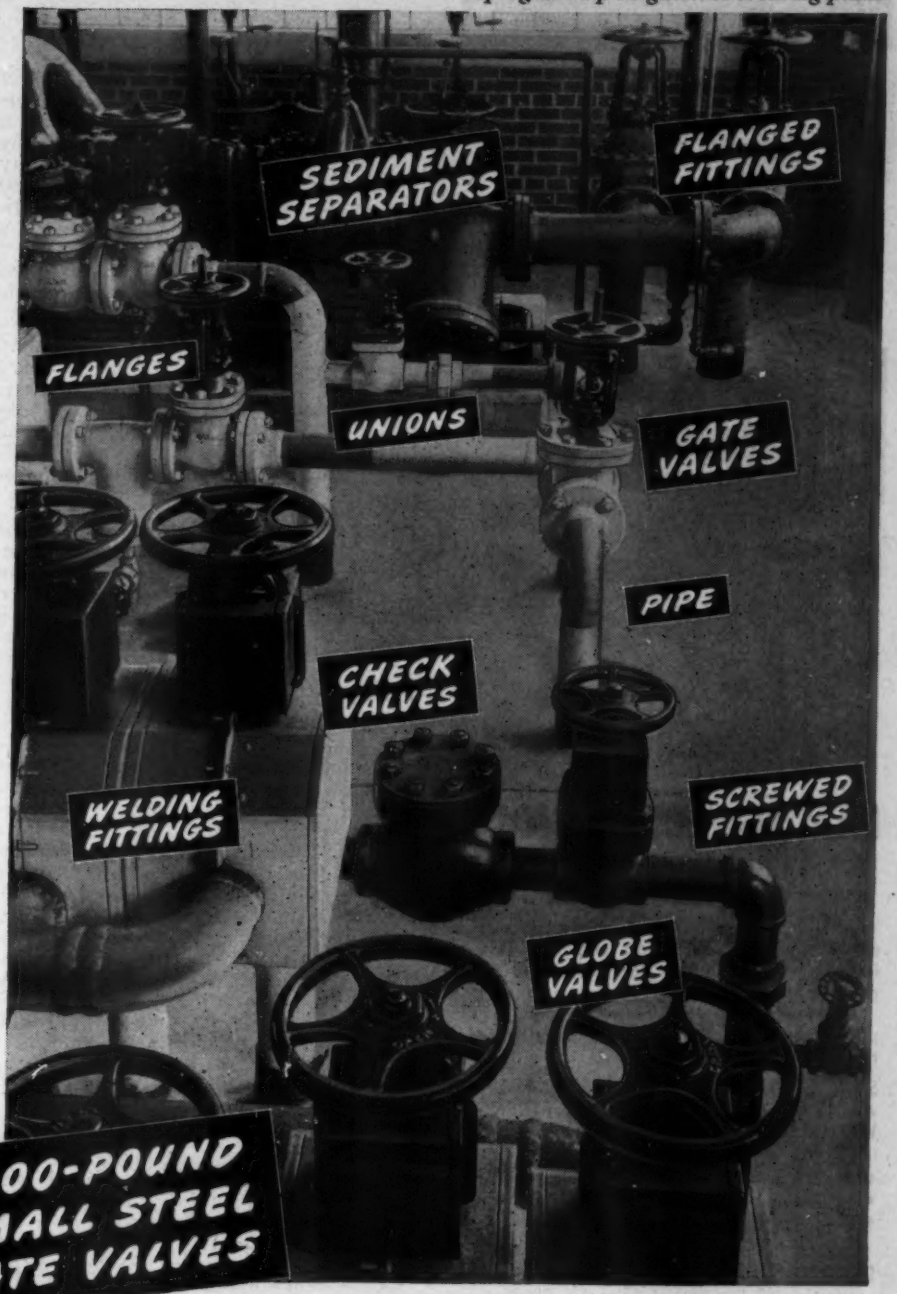


Literally under wraps, the jet burner being studied is too secret to permit photographs. At the right is a stainless-steel heater that utilizes heat from the jet burner to heat the compressed air that is being supplied to it.



Refinery piping systems ...equipped by CRANE 100%

Piping hookup in gasoline treating plant



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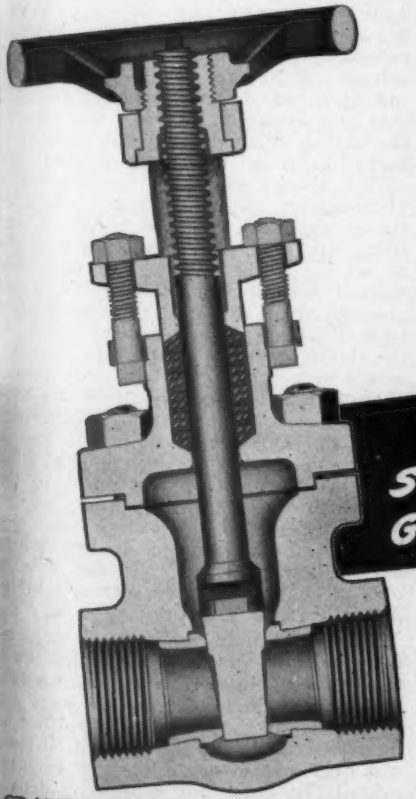

600-POUND SMALL STEEL GATE VALVES

SERVICE RECOMMENDATIONS: **Crane Small Steel Gate Valves** are made for a wide variety of services in oil refineries, oil and gas fields. Exelloy trimmed valves are recommended for oil and oil vapor services at temperatures up to 1000° F. "W" trimmed valves for steam, water and general services up to 750° F. In sizes up to 2"; bolted or union bonnet; screwed, flanged or welding ends. Globe and Angle Valves are also available. See your Crane Catalog for complete specifications.

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Fractional Distillation of Petroleum

ROBERT EDMUND HANDSCHUMACHER
Science Talent Search Finalist, Abington Senior High School
Abington, Pennsylvania

BECAUSE the distillation and refining of petroleum embodies all the basic principles used in organic chemistry, Robert Edmund Handschumacher, 17, of Glenside, Pennsylvania, chose this as a research project. His description of his work was one factor in selection of his as one of 40 finalists from 15,000 high school seniors participating in the Science Talent Search conducted by Science Service. He was awarded an all-expense-paid trip to the Science Talent Institute in Washington, D. C., and a $100 Westinghouse Science Scholarship.

A student at Abington Senior High School, Handschumacher has been president of his last three high school classes and has made the honor roll 11 times. He placed fourth on the mathematics examination team at Temple University.

THE keynote to tomorrow's world seems to be advances in organic chemistry. For this reason I have devoted a considerable portion of my leisure time for the past few years working in my home laboratory to gain a practical working knowledge of some of the rudimentary procedures in this field. As a particular subject for close research I chose the distillation and refining of petroleum since it embodied all the basic principles used in organic chemistry.

Despite the lack of regular equipment, I have been able to do some primary and secondary distilling with moderate success. As a starter in this field I obtained a batch of low-grade crude oil rejected by a nearby oil company. This I distilled in a home-made condenser operating between 150 and 200° C.

The oil fraction obtained from the condenser was chiefly a mixture of petroleum ether, naphtha, and gasoline but was highly poluted with foreign matter. This fraction was impure because it contained free sulfur, carbon, and several gases. To correct this the fluid was filtered through regular filter paper since Fuller's earth which is commonly used in industry was not available. This still did not give complete results so I replaced the filter paper with extra fine paper and applied suction to speed up the process. This proved far more successful and resulted in a clear product that looked pure but still had a foul odor rather than the rather pleasant odor of regular naphtha. To correct this I washed the oil fraction with sulfuric acid by playing a small stream of the acid from a wash bottle through the liquid. To correct the low ph introduced by the acid, I washed the fraction in a similar manner with sodium hydroxide solution and then with water.

This product obtained seemed to resemble regular naphtha rather closely so I tried it in my model airplane motor, only to find that it would cause the motor to backfire before the compression stroke was complete. Mixed with gasoline in ratios of 3:2 or 2:1, it worked provided the engine was kept at a low operating temperature. Since this extra rapid combustion was due to a rather large percentage of petroleum ether in the fuel, I placed some of it in a retort and heated it to 70° C. to drive off any petroleum ether, leaving a residuum of naphtha and gasoline. When this was used with the motor there was little trouble getting it started. However, continued operation with this fuel revealed an unduly heavy carbon deposit on the piston head. Since I have at hand no apparatus with which to safely handle pressure, further refining of this fraction must wait till adequate equipment is available.

Turning to the heavier fraction obtained from the initial distillation, I directed my efforts toward reducing the molecular weight of these oils. After treating them with the sulfuric acid, sodium hydroxide, and water, I was ready to attempt to crack" them. Since cracking is, in its simplest form reducing the number of CH_3 groups, my first attempts were designed to partially oxidize the fraction. This was done by passing the vapors over red hot iron which was heated by electrical resistance to avoid open flames. The resultant oil seemed even heavier than the first, but several filterings revealed that the apparent increase was due to the sludge formed, and that actually it had thinned out to a certain degree. To verify these results I constructed a viscosimeter along the same lines as those used in industry today. Using some oils of known viscosity I was able to set up a chart to fit my particular meter. Noting that the viscosity increased with the molecular weight, I took this fact and based my work on the theory that any increase in viscosity would be accompanied by a proportional change in molecular weight if the temperature was kept constant. While there were, no doubt, many other factors in the above conclusion was logical. This fact I confirmed by references to the viscosity of separate members of the paraffin series. Using these facts and a table of the various boiling points in the paraffin series I was able to note a change in molecular weight induced by this "cracking" process.

Since aluminum chloride is successfully used in industry as a catalyst, I tried several times to speed the reaction by passing the hot vapors over the chloride; but the pressure could not be increased safely, so the reaction, if there was one, was so negligible that even repeated trials did not produce a detectable difference.

By the above method I was able to detect an approximate change in molecular weight in the original sample from about 282 to 226. Beyond this point, however, cracking by partial oxidation failed to achieve desired results, for below this point the oil oxidized rapidly

into carbon dioxide, water and free carbon.

Having gone this far in the work, I now feel the need for some more accurate equipment, so over the holidays I'm making plans for an electrically controlled sand bath so that with definite temperature control, the fractions first obtained may be closely divided into smaller constituents. I have made several arrangements to visit some industrial laboratories where I will actually be able to see fractional distillation in practice and compare my technique with theirs.

Through this project I have been introduced to several of the fields in organic chemistry that are closely related to the petroleum industry. The most fascinating of these is the work that is possible in synthesis. Now I feel that I have acquired enough laboratory technique and related data to begin some pure research in the synthesis of other organic substances beyond the realm of petroleum.

Selective Repeal Wartime Measures Suggested by CED

Full return to a normal economy will require 30 months after the defeat of Japan, the first 6 months for reconversion and the following two years for gradual return to normalcy, it is estimated by the Committee for Economic Development.

A program for the removal of wartime controls has been developed by the research committee of CED, calling for selective rather than indiscriminate repeal of wartime measures.

"For some controls," it was explained, "the emergency may end largely with victory in Europe, for others, with victory over Japan; for others, especially anti-inflation measures, it may extend for a considerable period thereafter.

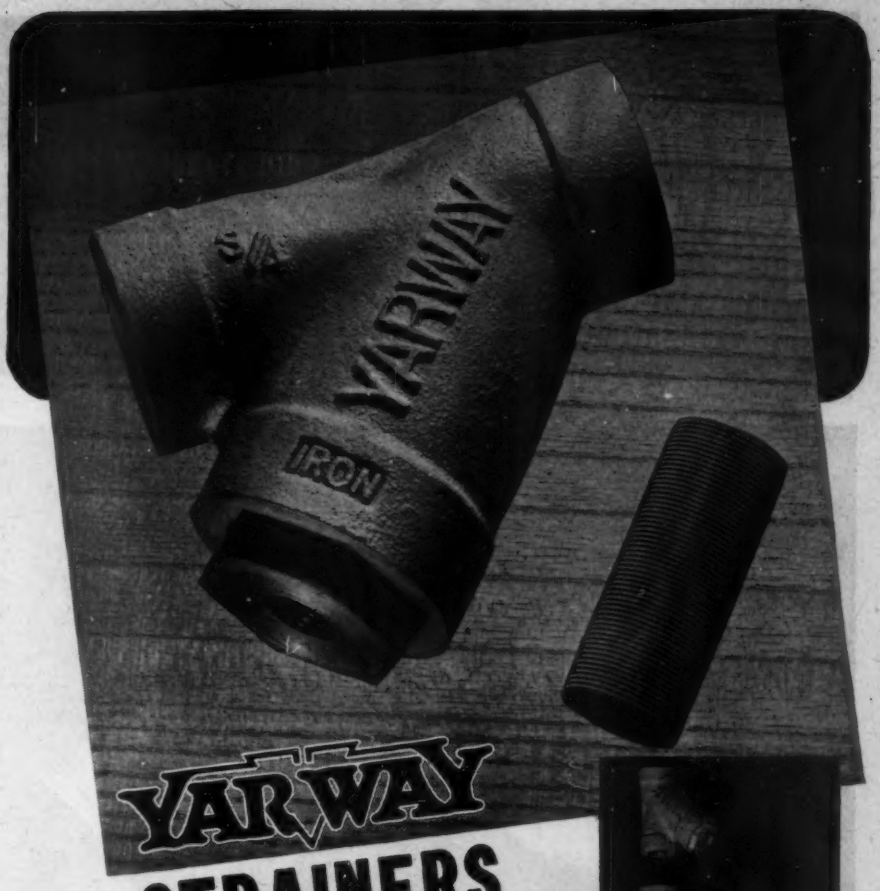
The oil industry would benefit by adoption of the committee's recommendation that in the field of price control general advances should be resisted but adjustment should be permitted prices which deter production, with the objective of "a level of prices high enough to induce the required expansion of production and employment, and low enough to maintain the necessary consumption under normal conditions of supply and demand."

Continuation of import and export controls until production has relieved domestic shortage of civilian goods was urged.

The proper timing of action will be the most important factor in the transition from war to peace, however, it was asserted. Too abrupt removal of controls will raise dangerous situations, but other and equally dangerous conditions may result if they are retained too long.

Suggestion Awards Made

Awards totaling $350 will be presented by Cities Service Oil Company to Oscar Ledbetter and Lewis Scott of Ponca City, and Earl Y. Palmer of Holdenville, Oklahoma, in recognition of outstanding suggestions submitted in 1944 for improvement of company operations and earnings. The suggestions which applied to refinery and chemical operations were selected from a large number submitted by employes during the year. Awards averaging $18.30 per suggestion accepted were paid out in war bonds and stamps.



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YARWAY STRAINERS are *selling by the thousands* because they are better engineered for the service.

"*The Screen is the Thing*"—a high-grade, woven Monel wire screen that stops the dirt, lets fluids flow freely.

Then, too, purchasers like the *body finish*—*Cadmium plating inside and out* for protection against corrosion.

And last but not least, it is "*Easy to Clean*" having a steel blow-off bushing, precision machined with straight thread. Screen and bushing come out together—go back together, automatically aligning.

Six sizes, ½" to 2" for pressures up to 600 lb serve practically all strainer needs.

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For data on Yarway Fine-Screen Strainers, see page 1023 of the 1944 Refinery Catalog.

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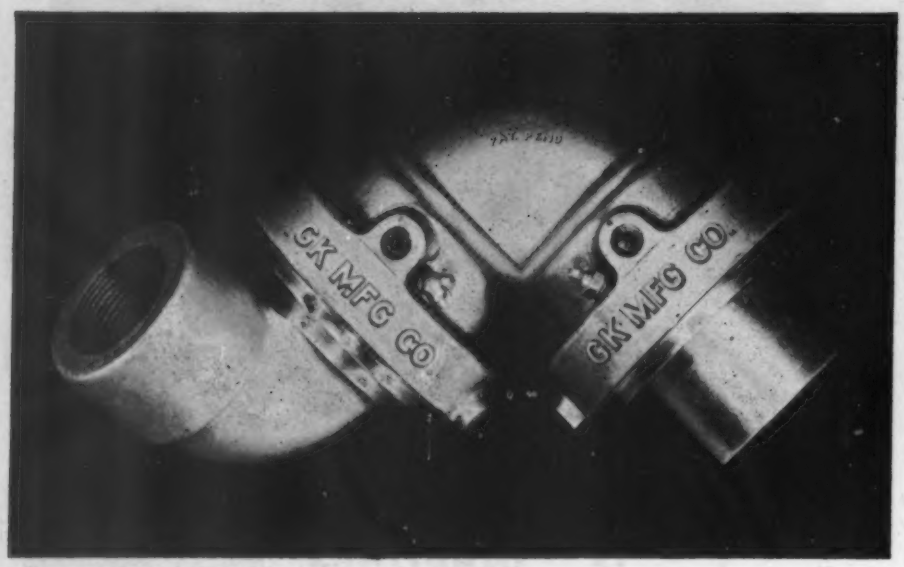
NOW A PLASTIC PACKED SWIVEL JOINT



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Natural Gasoline Association Elects J. H. Dunn President

The board of directors of the Natural Gasoline Association of America, meeting at Dallas on May 2 in lieu of the annual membership gathering of the association, elected the following officers: J. H. Dunn, Amarillo, president; Paul M. Raigorodsky, Tulsa, J. B. Atkins, Shreveport, and C. R. Williams, Houston, vice presidents.

J. H. DUNN

Companies elected to serve on the board of directors for a two-year term are: J. S. Abercrombie Company, Hagy, Harrington & Marsh, Sun Oil Company, Continental Oil Company, Cities Service Oil Company, Barnsdall Oil Corporation, Lone Star Producing Company, Owens, Libby-Owens Gas Department, Parade Company, Shamrock Oil and Gas Corporation, Shell Oil Company, Inc., Union Oil Company of California, and Virginia Gasoline and Oil Company.

Directors of Natural Gasoline Supply Men's Association which normally meets with the Natural Gasoline Association recently met at Tulsa and continued its officers in their positions until war conditions permit a meeting of the membership.

James E. Pew Gets Wartime Hanlon Award

The Hanlon Award was conferred May 2 on James E. Pew, director of the Natural Gas-Natural Gasoline Division of Petroleum Administration for War. The ceremony took place at the annual meeting of the board of directors of the Natural Gasoline Association of America, at Dallas.

Pew is the ninth recipient of the Hanlon Award which is conferred each year for outstanding meritorious service to the natural-gasoline and condensate industries.

Presentation was made by James W. Vaiden, president of the association, at the luncheon for the Directors. The citation read in part: ".....his untiring efforts in coordinating the wartime activities of the natural-gasoline and condensate industries with those of the

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HIGH PRESSURE—LOW PRESSURE—HIGH TEMPERATURE—LOW TEMPERATURE LIQUIDS—VAPORS OR CHEMICALS . . . FITTING STYLE OR MAINTENANCE QUESTIONS

Nothing pleases us more than an opportunity to *prove* that Flexitallic Gaskets can handle sealing jobs better than they've ever been handled before — and far better than is possible with either conventional or so-called "special" gasket types. That has been our sole job for 33 years.

No other gasket can seal so perfectly because no other gasket incorporates the design features which make Flexitallic supreme for difficult applications. Spiral-wound construction automatically compensates for pressure surges, vibration, expansion, contraction. Bolt tension is controlled by gasket yield. Seal with Flexitallic — and it stays sealed.

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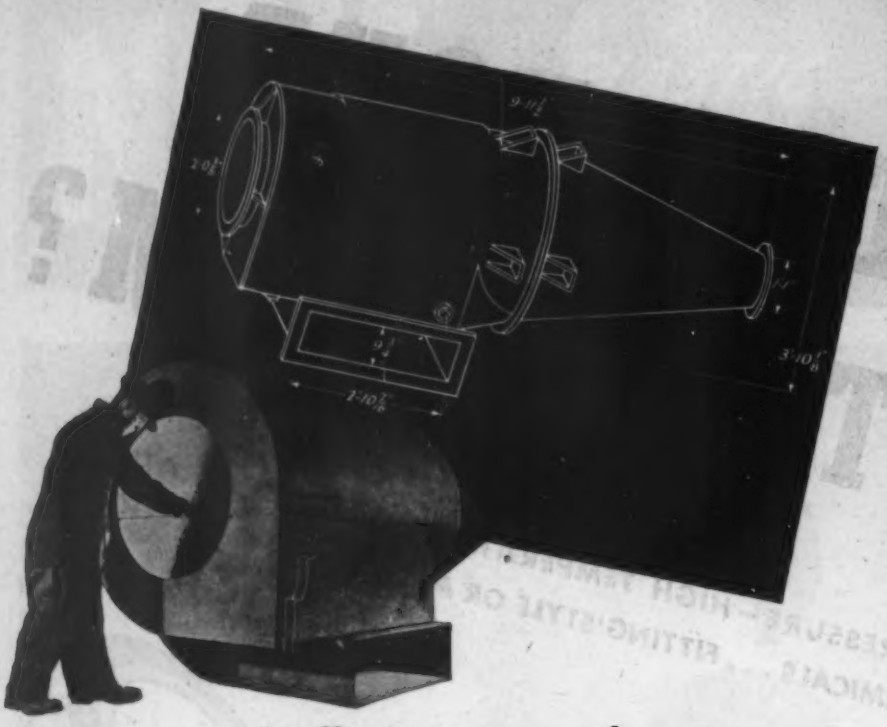
Flexitallic Gaskets are regularly supplied in styles for American standard flanges and pressure vessels of all types and for extreme pressure and temperature ranges. Our engineers welcome the opportunity to acquaint you with the possibilities of these unique gaskets for your applications.

THE ORIGINAL SPIRAL-WOUND GASKET . . . MADE ONLY BY FLEXITALLIC

LARGE DIAMETERS



Buell's assurance of
HIGH EFFICIENCY, LOW MAINTENANCE, LONG LIFE

THE DECIDED ADVANTAGES of Buell's large diameter cyclones, made possible by the patented "Shave-Off", definitely reflect industry's growing preference for Buell (van Tongeren) Dust Recovery Systems.

Large diameters make possible a collection operation with low centrifugal force and permit construction of extra thick steel. This accomplishes two things: minimum abrasion and long life. *Large diameters* afford large dust outlets, making clogging practically nil. *Large diameter* cyclones have the added advantage of handling a given gas volume with fewer units.

Engineers who look to low cost up-keep and continuous operation as prime requisites in dust recovery should give these factors serious consideration.

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CORRECT HOPPER DESIGN
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RESULT IN

HIGH COLLECTION EFFICIENCY
LESS FAN BLADE WEAR
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UNLIMITED CAPACITY
NO MOVING PARTS
FREE DUST FLOW

PRODUCE

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LOW OPERATING COST
LONG LIFE
NO CLOGGING

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Engineers and plant executives are invited to write for Buell's factual 28-page book:
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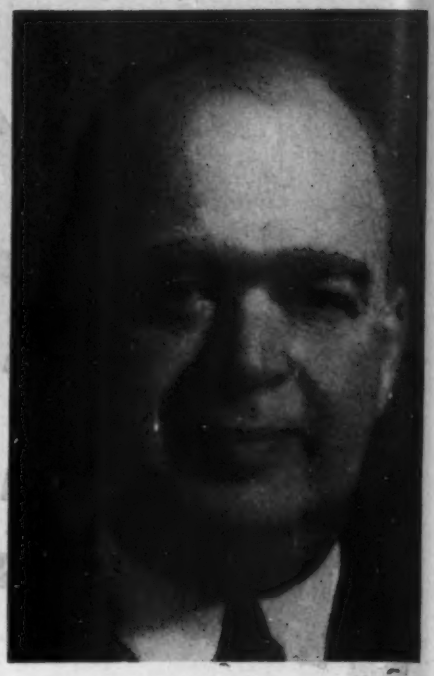


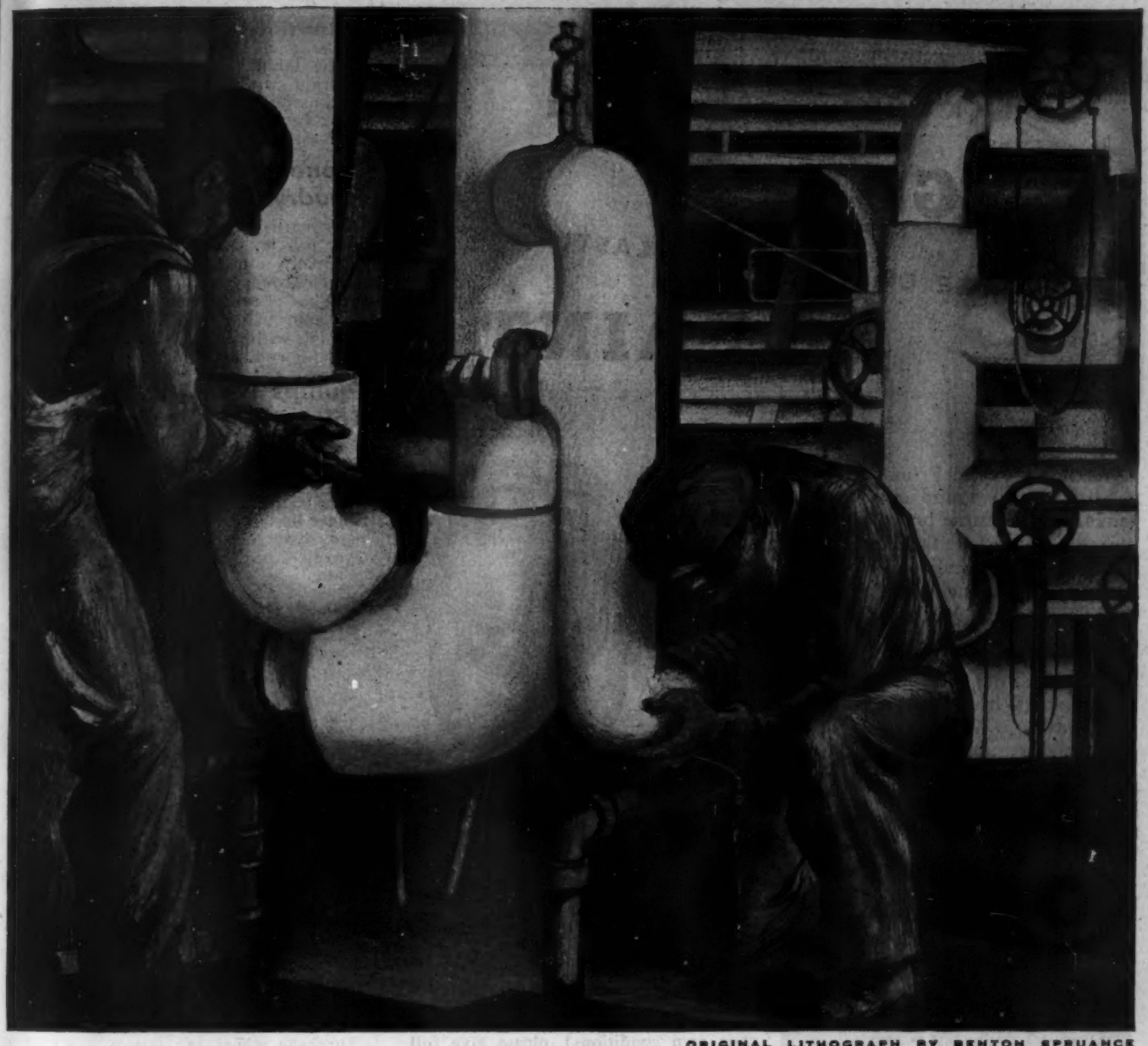
JAMES E. PEW

entire oil program; his continued and forceful advocacy of a broader use of the products of the industries in the manufacture of critically needed war materials; and the effective manner in which he stimulated and directed the production and distribution of products for which there was the most pressing need, not only resulted in a great contribution to the total war effort but brought a new realization to the industries he represented of their own potentialities."

Pew attended Cornell University and Massachusetts Institute of Technology. On graduation in 1923 he was employed by United Natural Gas Company at Bradford. From 1924 to 1926 he was employed by Hope Construction and Refining Company, for whom he worked in the Mellon Institute on research and development studies in connection with natural gasoline and liquefied petroleum gases. In 1926 he became associated with Virginian Gasoline and Oil Company, Charleston, West Virginia where he advanced to superintendent of operations and later was also made manager of Viking Distributing Company, a subsidiary. In 1942 he was called to Washington as a member of the Production Division of the Petroleum Administration for War. When the Natural Gas-Natural Gasoline Division was formed in June, 1942, Pew was made chief of the Natural Gasoline Section, and in July 1943 he became assistant director of the division. In November 1943 he was appointed director of the division.

Contract Let for Shale Research Laboratory

The United States Bureau of Mines has let contract for construction of the building for its shale research and development laboratory at the University of Wyoming, Laramie. The building will cost $534,000, and is to house facilities for laboratory and small pilot-plant experimental studies on processes for refining shale oil, retort testing and development, and other research. Provision also is made for offices, library, machine shop, drafting and other needs of the 70 additional technical and ad-

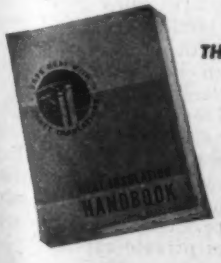


ORIGINAL LITHOGRAPH BY BENTON SPRUANCE

Fighting Btu's

THE Btu's produced in boilers and distributed through steam lines are not only fighting the wartime battle of production. They also fight, year in and year out, to escape in the form of heat losses. Industry's effort to prevent the waste of heat is never-ending.

The battle against heat loss is as broad as all industry. With every boiler, steam line, fitting and heated surface a potential avenue of waste, they should be amply protected with a highly efficient thermal insulation such as Ehret's 85% Magnesia or Enduro. These time-defying insulating materials have been conserving heat in countless installations for nearly half a century. Those who specify or use these materials like them because they are dependable, economical and trouble-free.



THE EHRET HEAT INSULATION HANDBOOK *contains a wealth of information on 85% Magnesia, Enduro high temperature and many other insulations — with selection and application data for boilers, piping and equipment. Fully illustrated, it includes heat loss and efficiency tables, specifications and recommendations for every temperature condition. A copy will be sent at your request.*

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A COAT of Tygon Primer and a few top coats of Tygon Paint applied to exteriors of tanks, pumps, fume hoods, ducts, pipe, exposed structural work—in fact, any place where danger of corrosion from acid spillage, gases or condensates is prevalent—gives lasting protection against almost all acids and alkalies.

Tygon Paint is a liquid formulation of Tygon sheet stocks, the rubber-like plastic used to line acid tanks. While thin (as any paint film) compared to a 3/32" thick Tygon lining, Tygon Paint possesses the same basic corrosion-resistant properties of Tygon sheet stocks. Tygon Paint films are tough and flexible. They are resistant not only to most chemicals but to water, oil, grease and alcohols. Like other Tygon formulations Tygon Paint is not subject to oxidation, will not chemically deteriorate with age.

Tygon Primers and Tygon Paints are applied cold with spray gun or brush. May be applied to any clean metal, wood or concrete surface. May be air-dried or baked.

Tygon Paint is available in white, black, clear, grey, green, red and aluminum. In requesting samples (available without charge for test in your own plant under your own conditions) please give full details as to the proposed use: corrosives encountered, temperature, and nature of surface.

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OTHER FORMULATIONS OF TYGON *FLEXIBLE* PLASTICS

TYGON LININGS—Tygon sheet stocks are used to line acid handling and storage tanks, blowers, valves, pipe, fume ducts, and other equipment exposed to severe corrosive conditions. Tough, sturdy, highly resistant to abrasion, Tygon linings bond to steel with almost integral adhesion.

TYGON GASKETING—for effective pressure-tight seals in chemical handling service. Tygon gasketing is available in sheets, in extruded tubes, rods, strips, ribbon or tape from which you can cut your own gaskets, or Tygon gaskets may be molded to your exact specifications.

TYGON TUBING—a tough, flexible tubing for air, gas, or fluid transmission. Translucent or opaque, in diameters up to 1¼", and in varying wall thicknesses. Formulation S-22-1 is ideal for laboratory use: flexible and elastic for easy connections, and clear for solution visibility. S-22-1 may be steam sterilized.

TYGON MOLDED ITEMS—Tygon molds much the same as rubber. Physical, chemical and electrical properties may be varied within a wide range to suit highly individualized requirements.

ministrative employes to be stationed at Laramie.

The laboratory will operate in conjunction with the $1,500,000 oil-shale demonstration plant upon which initial work is underway on a Naval Reserve in Western Colorado.

Leonard Refineries Plans Houdry Unit in Michigan

Leonard Refineries, Inc., Alma, Michigan, has let contract to The Lummus Company for construction of a 3000-barrel Houdry unit to be added to its 6000-barrel refinery at Alma. The project has approval of WPB and PAW, will be built with private funds, and is scheduled for completion January 1, 1946.

Phillips Will Operate DPC Toluene Plant at Borger

Construction of a toluene plant at a cost of $6,600,000 near Borger, Texas has been authorized by Defense Plant Corporation. The plant is to be operated under lease by Phillips Petroleum Company. Bechtel-McCone Company, Los Angeles, has contract to construct the plant.

Government Plans Toluene Plant at Lake Charles

The government plans expenditure of $20,000,000 on construction of a toluene plant adjacent to Cities Service Refining Corporation's refinery at Lake Charles, Louisiana. Title to the plant will be in Defense Plant Corporation, and it will be operated under lease by Cities Service.

Biddle Would Lease Government War Plants

Leasing of government war plants to potential buyers for such periods as may be necessary to determine their productive value, rather than their immediate sale on the best offer, has been recommended to Congress by Attorney General Francis Biddle.

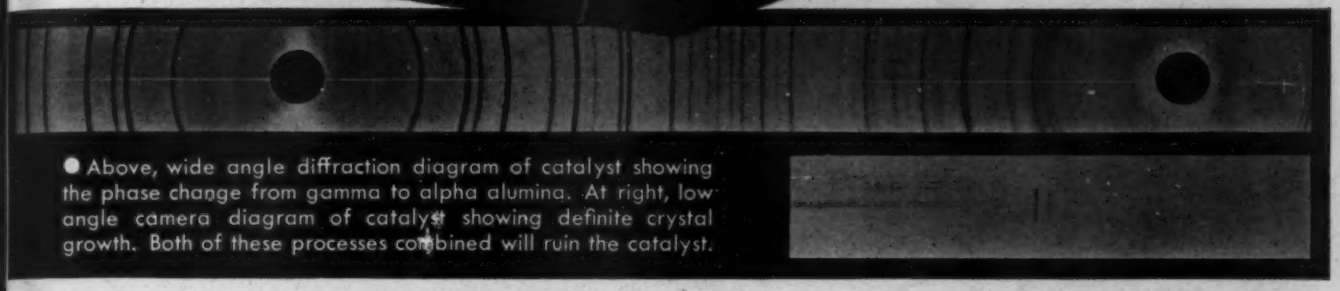
Biddle took the position that industry will be less reluctant to lease than to purchase where the future is uncertain and that the government itself may more readily ascertain the value of a property after its operation over a period of years.

Biddle proposed that leases contain options for sale at a price based on lease-hold earnings or to be fixed by arbitration. Other provisions, he said, should require bidders to state in detail the proposed future use of plants and facilities, and prohibit the closing of plants to eliminate competition, requiring the lessee to maintain a stated number of employes during the term of the lease to prevent it from reverting to the government.

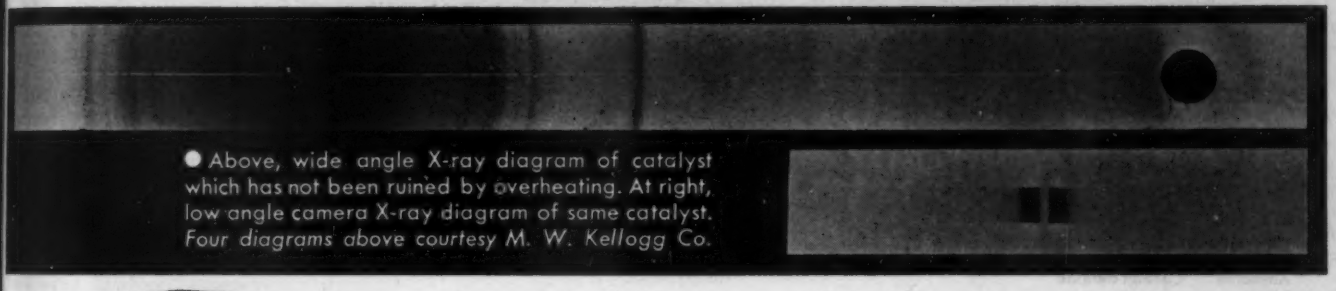
"Leasing of plants would not only give business and the government an opportunity to determine more realistically the ultimate sales price, but would encourage bidding by small businesses furnished with more limited capital resources than its larger competitors," Biddle declared.

"Leasing would tend to provide greater possibilities for the use of new processes and the production of products which have not been previously on the market. At the end of the leasing period sales can then be more easily consummated through the use of private capital."

OVERHEATING OF CATALYSTS



● Above, wide angle diffraction diagram of catalyst showing the phase change from gamma to alpha alumina. At right, low angle camera diagram of catalyst showing definite crystal growth. Both of these processes combined will ruin the catalyst.



● Above, wide angle X-ray diagram of catalyst which has not been ruined by overheating. At right, low angle camera X-ray diagram of same catalyst. *Four diagrams above courtesy M. W. Kellogg Co.*

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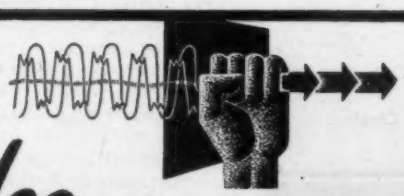

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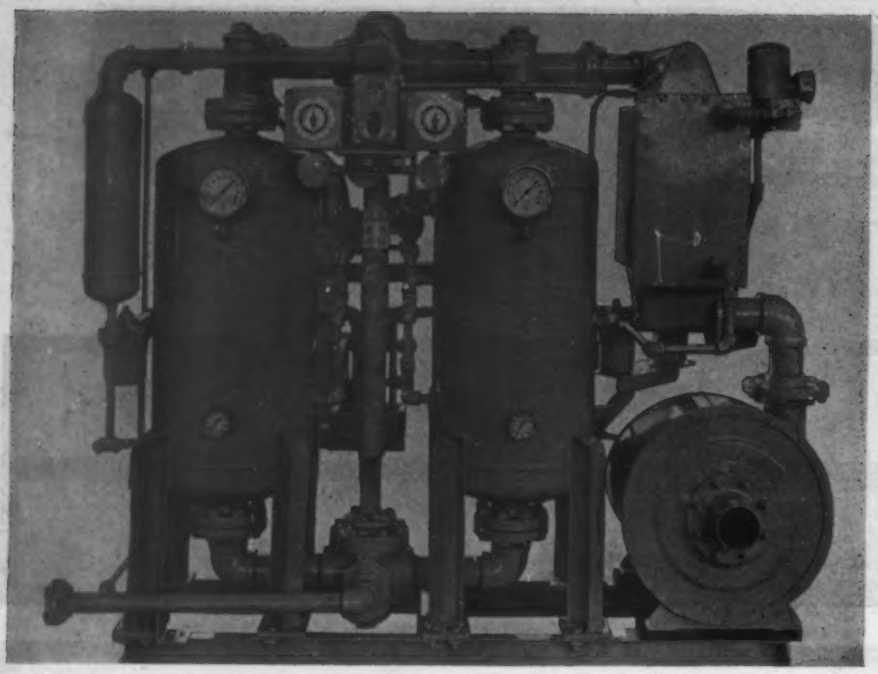

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KEMP of BALTIMORE

Biddle reported that studies are now being made of the synthetic rubber and aviation gasoline plants which the government will have on its hands at the close of the war.

As fast as they are declared surplus, machine tools and production equipment will be made available to all types of industrial users through the medium of public sales, the RFC, a disposal agency designated by the Surplus Property Board, has announced. The Army and Navy have removed all restrictions upon the sale of surplus machine tools and production equipment.

Industry Is Urged To Save Scrap Iron

Inventories of heavy melting scrap have declined so that steel mills are threatened with having to suspend operations in some localities. At this time inventories comporise mainly the lighter grades of scrap, alloys, etc., so that there is not enough of the heavy grades available to combine with the lighter grades to make proper charges to steel furnaces.

A much greater flow of heavy melting scrap is badly needed to balance the furnace charges and prevent shut-downs.

The Conservation and Salvage Division of War Production Board is calling upon the petroleum industry to resume its salvage activity and make every effort to accelerate movement of heavy melting scrap to the mills.

Poland's Gasoline Supplies Greater Than Before War

The government of Poland says current production capacity of motor fuels is "several times as great" as in 1939. This is because field and refining facilities, expanded during the German occupation, have been recovered in good operating condition but mostly because of the capture of the German-built synthetic oil and rubber plant at Oswiecim, which is rated as being capable of producing more than 1000 barrels of gasoline per day, according to Russian engineers now supervising operation of the plant.

Synthetic Fuels Research Budget Request Curtailed

Slashing $9,945,690 from its budget estimates and $3,563,230 from its current appropriation, the House appropriations committee recommended that funds for the Bureau of Mines during the coming fiscal year be limited to $15,881,860.

The committee cut $7,000,000 off the fund for synthetic liquid fuels investigations, for which the bureau asked $13,000,000, of which $9,700,000 was for construction of the hydrogenation and gas synthesis demonstration plants. The bureau had $5,000,000 for this project this year.

The committee also refused to permit the bureau to expand its oil and gas investigations, lopping $78,640 from the budget estimate to provide only $579,000, a decrease of $4000 from the current fund. The only other cut affecting oil operations was $1600 taken from an estimate of $80,000 for a new project in helium utilization and research.

Appraised of the action of the committee in curtailing the fund for synthetic fuel research, Senator Joseph C. O'Mahoney said he would fight to have the $7 million restored when the bill reached the Senate.

THE SUPER.....

was tearing his hair

The main water supply pump for the new plant refused to stay primed. The Superintendent was "wild." No one had anticipated trouble here; it was probably the simplest pump installation in the whole plant.

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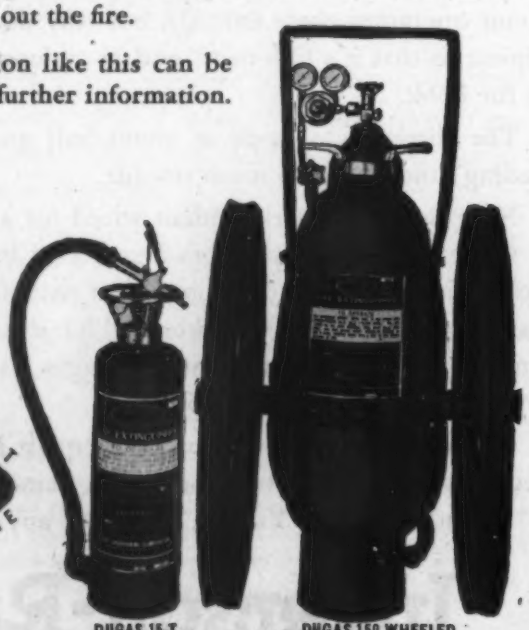

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Large Increase In Naval Oil Needs Seen for 1946

Expanding operations during the coming fiscal year will require 154,358,000 barrels of fuel oil at an average cost of $1,221 per barrel, it was estimated by Rear Admiral W. J. Carter, chief of the Bureau of Supplies and Accounts, testifying before a House appropriations subcommittee on the naval supply bill for 1946.

This will be an increase of 27,860,750 barrels more than the revised estimate for the current year. The fleet is scheduled to total 2121 vessels, an increase of 93, and Carter expained that the disproportionate increase in fuel-oil requirements will be due to the fact that many of the vessels delivered this year have been in service only for a brief period and there will be an over-all increase in distances covered and the rate of operations as the war swings into high gear in the Pacific.

The minimum price paid by the Navy for fuel oil, he said, is 95 cents a barrel picked up at Aruba. About 5,356,000 barrels of oil more than the undisclosed amount provided this year is expected to be obtained under reciprocal lend-lease.

Diesel oil requirements of the Navy were placed at 37,211,000 barrels, an increase of 4,581,000 barrels, and gasoline, other than aviation, will cost $49,463,280, an increase of $16,325,450.

Natural Gasoline Reaches New High During January

Daily average production of natural gasoline and allied products reached a new high in January at 13,011,000 gallons as a result of a 22 percent increase in Texas Panhandle output and 11 percent in California, it was reported by the Bureau of Mines.

Figures on production of light products were further defined by the bureau beginning with January, as follows:

Natural gasoline, 177,932,000 gallons, natural gasoline mixtures, 28,015,000 gallons, and raw condensate, 42,513,000 gallons, against 181,062,000 gallons for all three in December; commercial butane-propane mixture, 31,135,000 gallons; normal butane, 39,464,000 gallons, propane 21,878,000 gallons, other liquefied petroleum-gas mixtures, 11,734,000 gallons, against 100,338,000 gallons for all four; iso-butane, 15,868,000 gallons; iso-pentane, 13,237,000 gallons, against 17,136,000 gallons for both; finished gasoline and naphtha, 18,552,000 gallons, and other products, 3,014,000 gallons, with no comparable figures.

The bureau reported that stocks declined 12,209,000 gallons during the month, those at refineries dropping from 98,574,000 to 89,292,000 gallons and those at plants and terminals from 88,368,0[illegible] to 85,441,000 gallons.

January Demand Drops, Allows Crude Stock Buildup

Production of crude increased in January by 61,000 barrels to 4,747,900 barrels daily, while demand for domestic crude dropped 68,300 barrels to 4,695,800 barrels, the lowest level since last August, permitting additions to stocks at the rate of 52,100 barrels daily after four months of steady withdrawals, the Bureau of Mines reported.

Crude runs to stills averaged 4,680,000 barrels a day, 1000 barrels under De-

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cember but 9 percent higher than January, 1944. January domestic production included 147,186,000 barrels of oil, 9,603,000 barrels of natural gasoline and 240,000 barrels of benzol.

No information was released regarding imports or demand for individual products, but January 31 stocks included 221,727,000 barrels of gasoline-bearing crude 6,026,000 barrels of heavy crude in California, 4,160,000 barrels of natural gasoline and 234,625,000 barrels of refined products, a total of 466,548,000 barrels.

A slight rise in the price index for petroleum and products was shown by Bureau of Labor Statistics indices, to 64.3 in January compared with 63.8 in December and 63.5 in January, 1944. The crude capacity represented by the bureau's refinery data was 5,030,000 barrels indicating an operating ratio of 93 percent gainst 90 percent in January, 1944, and 79 percent in that month in 1943.

Record-Breaking Payment Of Taxes Made in March

Lubricating-oil-tax payment collections in March were a record $9,901,856, more than double the $4,861,923 received in the same month last year, the Internal Revenue Bureau reported.

Gasoline-tax collections for the month totaled $34,898,193 against $25,643,262 last year, and receipts from pipe-line transportation were $1,444,661 against $1,483,119.

March collections brought revenue from gasoline for the first quarter to $95,257,763, compared with $61,823,186 last year; while lubricating oil returned $22,567,978 against $14,351,268, and pipe line transportation $4,052,255 against $3,900,984.

Receipts for the first nine months of the fiscal year on gasoline returned $298,430,202 against $207,446,828 a year ago; lubricating oil, $61,935,406 against $39,909,236, and pipe lines, $12,358,578 against $11,709,947.

Oil Accidents Increase In Severity During 1944

An increase in the severity rate of accidents in the petroleum industry for 1944, is reported by the Department of Accident Prevention of the American Petroleum Institute. Longer working hours per man combined with wartime shortages of materials were responsible for the increase.

With all elements of the industry working at top speed, the increase in accidents was not unexpected, the report said.

Paraffin Shortage Causes Export Curtailment Order

The Federal Economic Administration has embargoed exports of paraffin wax to Mexico, announcing that no applications to export will be considered but will be returned without action to the applicant.

The FEA explained that the restriction was put into effect "because of the present critical supply situation which makes it necessary to curtail the use of wax produced in the United States and impossible to continue to supplement Mexico's domestic production of wax."

No indication was given of how long the embargo would be maintained.

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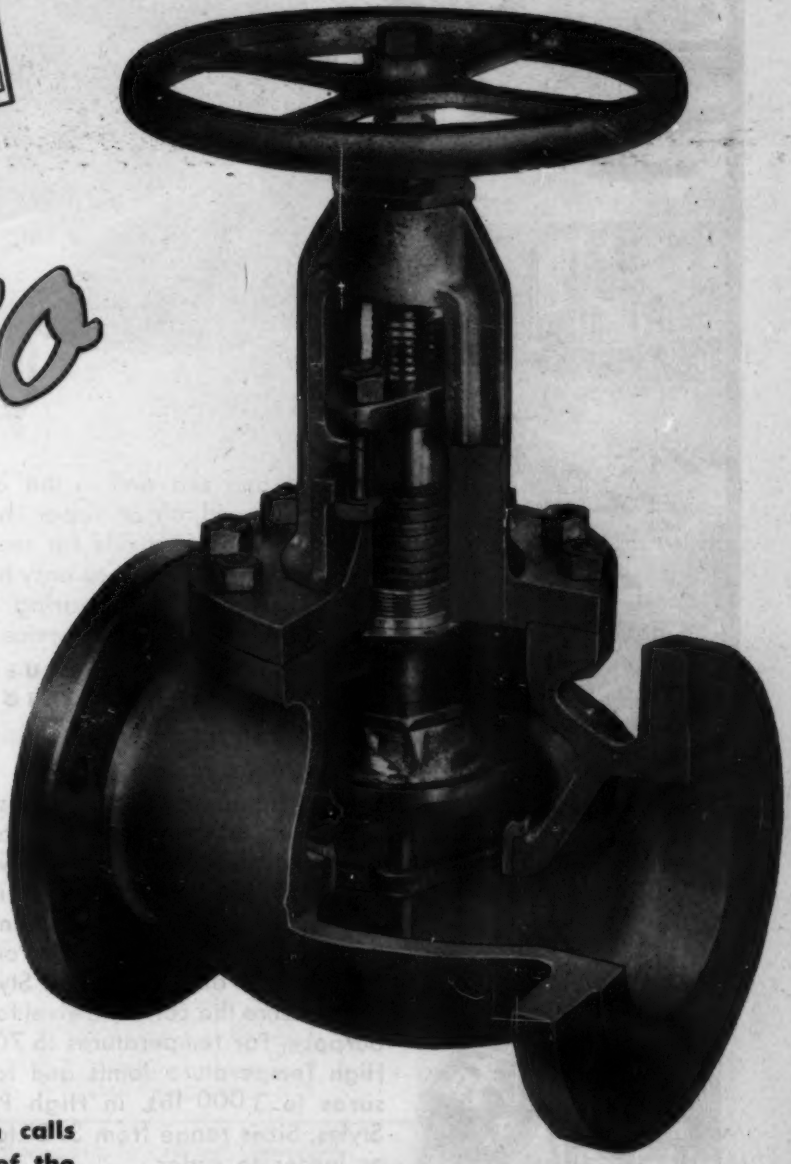

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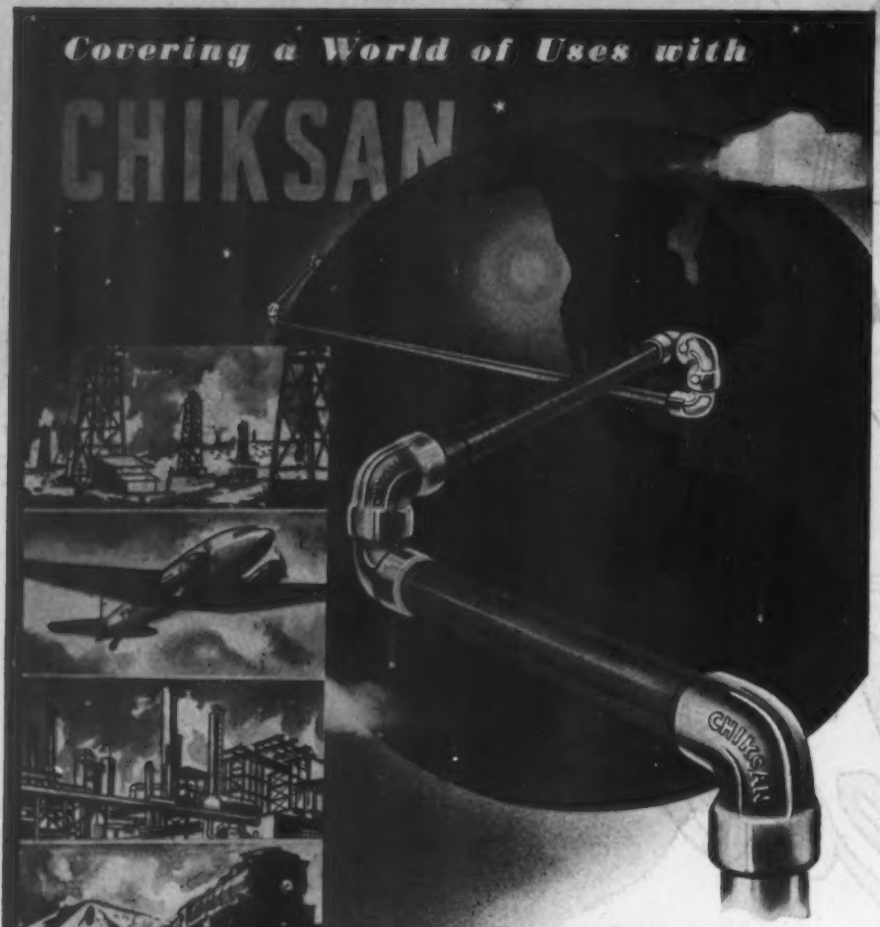

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Building 100-Octane Plant at Curacao

Shell-Mex has been given cooperation of Petroleum Administration for War in securing in the United States part of the equipment to be used in expending $6,700,000 for construction of a 100-octane unit as an addition to the Royal Dutch Shell refinery at Curacao, Netherlands West Indies. It is to be a twin fluid catalytic installation, from The M. W. Kellogg Company's blue prints. Orders for fabrication of items required from the United States to the amount of $1,650,000 have been placed, while other equipment items are to come from British sources.

Arkansas Natural Gas Makes Official Changes

D. W. Harris, president of Arkansas Natural Gas Corporation and subsidiaries, including Arkansas Fuel Oil and Arkansas-Louisiana Gas Company, has resigned effective May 15, and will be succeeded by T. W. Tutweiler, president of Cities Service Refining Corporation (Lake Charles refinery).

A. H. Weyland will be promoted to vice president and general manager, the latter position formerly held by Harris.

David Gordon With Foster D. Snell

David Gordon, recently chief engineer for Interchemical Corporation, has joined the staff of Foster D. Snell, Inc., Brooklyn, as director of engineering.

After securing chemical engineering degrees at New York and Columbia Universities, Gordon was engaged in research and development work with Consolidated Edison Company for six years. He then went with C. H. Leach Company where his principal attention was directed to heat transfer. As chemical engineer with Max B. Miller Company he designed and engineered the first large-scale two-solvent extraction plant, followed by several similar plants. Subsequently he was in charge of project engineering with the M. W. Kellogg Company.

Caminita Named Public Relations Director PAW

Ludwig Caminita, Jr., of Arlington, Virginia, has been named director of public relations for Petroleum Administration for War, succeeding Spencer W. Robinson. Caminita has been with the bureau since February 1942, was appointed assistant public relations director in April 1944, and has been acting director since Robinson returned to Houston in December, 1944.

Dr. R. H. Waser Retires

Dr. R. H. Waser has retired after 23 years with Shell Oil Company. He joined the organization as superintendent of the cracking department at Wood River in 1922. During the following 5 years he was superintendent at Arkansas City and at East Chicago, returning to Wood River in 1934 as superintendent, and becoming manager of that plant the following year. In 1937 he moved to Houston refinery as manager, remaining there until 1943 when he was given a special assignment, and was attached to the president's office until retirement.

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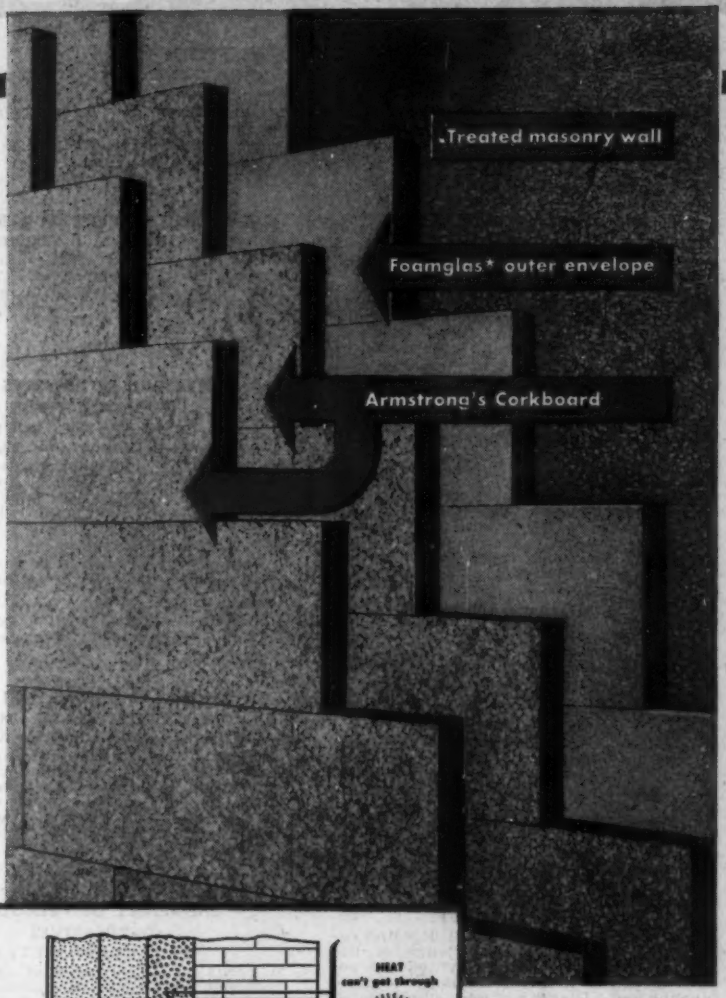

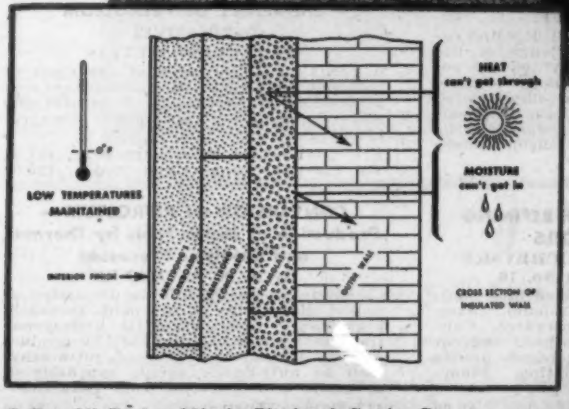

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◀ Diagram (at left) shows how Armstrong's new construction bars heat and moisture.

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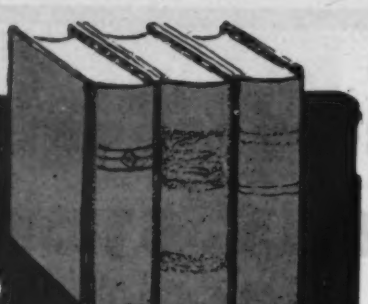

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Swann Research Director American Mineral Spirits

Dr. Ralph C. Swann has been appointed director of research of American Mineral Spirits Company, and will be located at the company's main office in Chicago.

Dr. Swann received his doctors' degree in organic chemistry from Massachusetts Institute of Technology and has had wide practical experience in research through his past association with several large companies in the petroleum industry.

Russell Will Help Evaluate Bomb Effectiveness

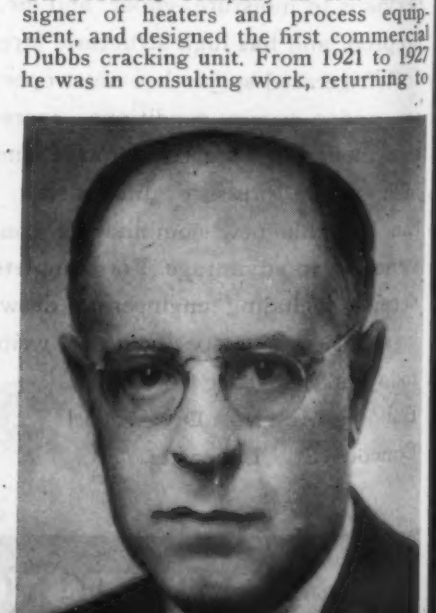
Robert P. Russell, president of Standard Oil Development Company, has been named a member of a nine-man civilian committee to appraise results of air bombing in Europe.

The committee, known as the United States Strategic Bombing Survey, will analyze the effect of air bombardment on the will and capacity of the enemy to resist. Findings of the survey are expected to aid in the war against Japan, and will provide data in studying the potentialities and future development of air power. A report will be submitted to the Secretary of War within a few months of termination of hostilities in Europe.

Mekler Consultant To Gas Institute

L. A. Mekler, combustion engineer with Universal Oil Products Company since 1927, now is engineering consultant to the Institute of Gas Technology and Armour Research Foundation of Illinois Institute of Technology.

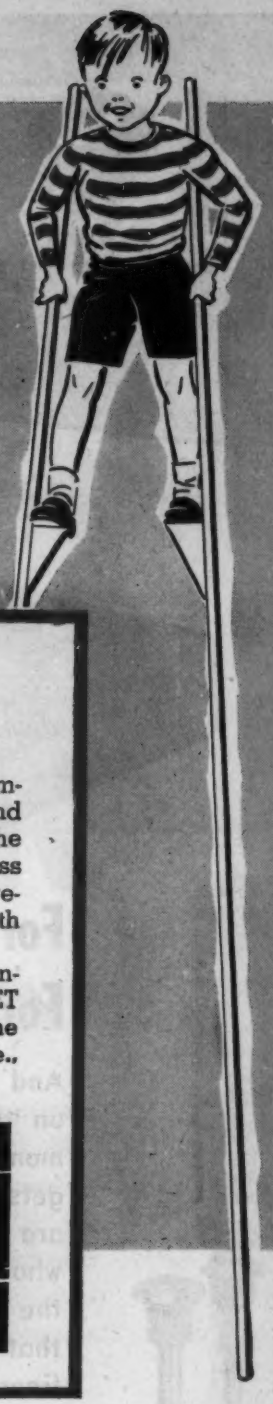
Born in Russia, Mekler had schooling at Harbin, Manchuria, at the University of Glasgow (Scotland) and University of California. He first joined Universal Oil Products Company in 1919 as designer of heaters and process equipment, and designed the first commercial Dubbs cracking unit. From 1921 to 1927 he was in consulting work, returning to



L. A. MEKLER

The kid's "got something"

...INSTINCTIVE BALANCE



It takes more than practice to avoid upsets in stilt-walking. You need *instinctive balance*, too. The instant you feel yourself going off balance, INSTINCT tells you how much and how quickly to shift weight . . . and you're in balance again.

In process control, that's called HYPER-RESET

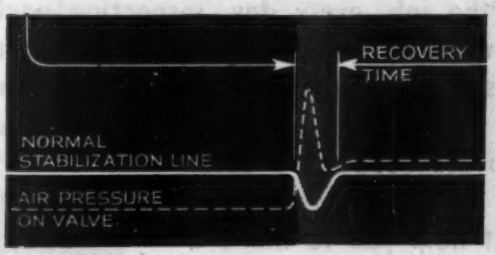
In process control that instinct for instantly responsive balance is the function of HYPER-RESET. It "feels" the rate of change of any disturbance at the very outset . . . and instantly effects the right amount of corrective action. This reduces recovery time to a fraction of the best previous time.

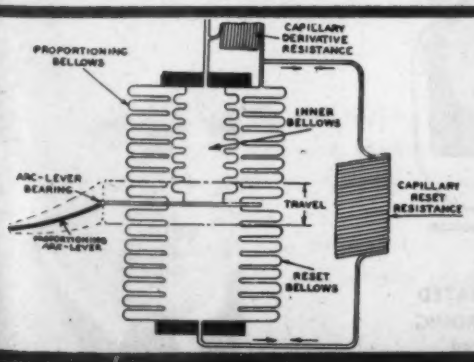
Without this rate sensing action, every disturbance is permitted to develop and continue to a greater magnitude. The

final result can be a serious upset in product uniformity.

In contrast, see the extremely brief recovery time in the process control curve of the Foxboro Stabilog Controller with HYPER-RESET (below). Rate sensitive action and reset function are combined, with *just one adjustment*, and both are smoothly coordinated with the proportional function for normal process stabilization. Recovery time is often reduced to a quarter of the usual time, with upsets held to new minimums.

For further details of Stabilog Controllers with the unique HYPER-RESET function, write for Bulletin A-330. **The Foxboro Company, 74 Neponset Ave., Foxboro, Massachusetts, U. S. A.**





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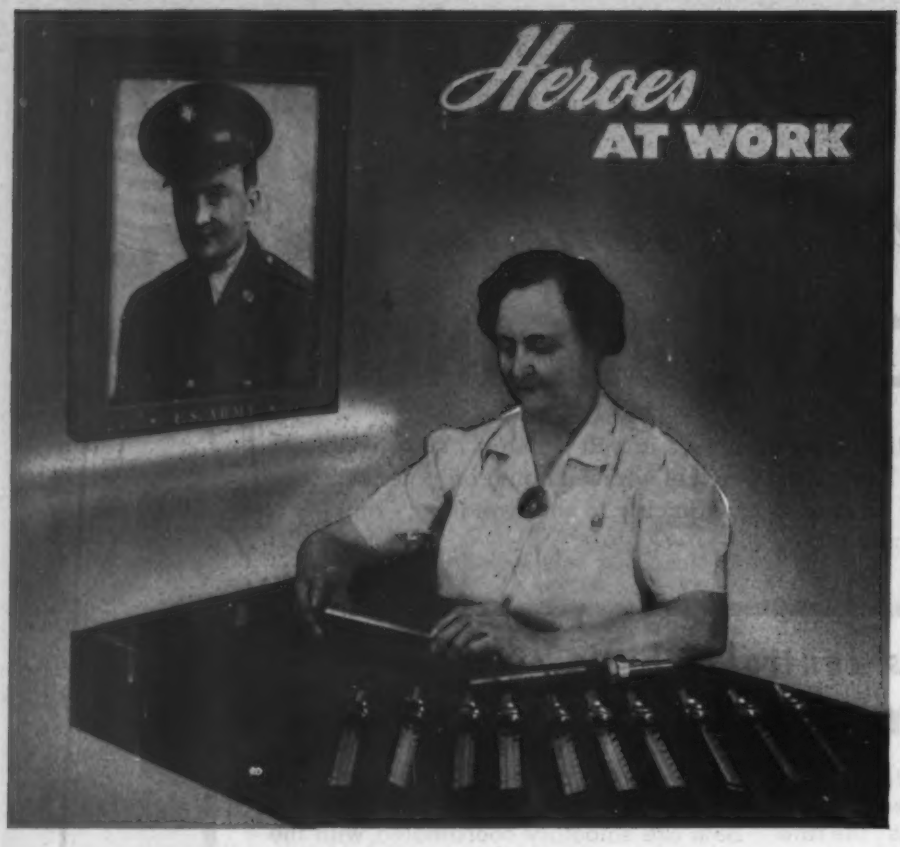

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Universal in 1927, his work was concerned with development of heaters for petroleum-refining processes, utilization of liquid and gaseous products and of petroleum coke as fuels, high-temperature metals and refractories, and development of processes and equipment for thermal and catalytic refining. During 1942 and 1943 he was on leave with PAW at Washington as consultant to the foreign division, particularly in supplying refining equipment to the Russians. He holds a number of patents relating to his work, and has contributed extensively to the literature.

Pettyjohn Named Director Institute of Gas Technology

Commander E. S. Pettyjohn, USNR, has been named director of the Institute of Gas Technology, succeeding John I. Yellott who has become director of research for the Locomotive Development Committee at Baltimore. Until Pettyjohn's Naval assignment is terminated, L. J. Willien, associate director, will be in charge.

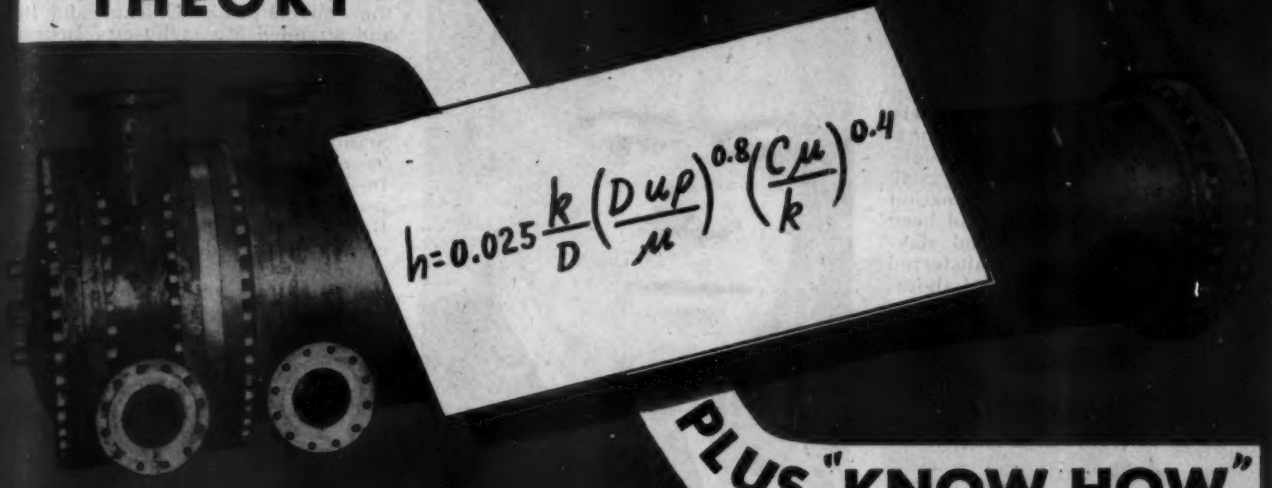
Pettyjohn is a graduate of University of Michigan, and in addition to several years of industrial and research experience, was an associate professor of chemical engineering at the University of Michigan before joining the Navy in 1940.

Carney Resigns Shell Connection

B. R. Carney has resigned as manager of the gas-gasoline division of Shell Oil Company, Tulsa, effective May 1. He joined the company on a refinery construction project and worked for more than eight years as technologist and chief technologist at the East Chicago, Indiana, refinery and over three years in the New York office as chief technologist in the supplies department. He was transferred to the gas-gasoline division of the Mid-Continent area in 1938, and has been manager of the division for the past six years. Carney has announced no immediate future plans and his succesor has not yet been named.

R. B. CARNEY

THEORY



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Fisher Elected Standard of New Jersey Vice President

H. W. Fisher, manager of the chemical products division of Standard Oil Company of New Jersey, has been elected a director of the company. He graduated as a chemical engineer at Massachusetts Institute of Technology in 1927, and started work immediately with Standard Oil Company of Louisiana at Baton Rouge, working on high-pressure hydrogenation of oil and coal. He continued work on hydrogenation development until after plants had been constructed at Baton Rouge and Bayway refineries, and then was transferred to what are now known as Esso Laboratories at Bayway. For a time he was assistant director of the laboratories. In 1936 the company organized a chemical products department with Fisher as manager. This department has grown rapidly, and today the company's interests include such diverse products as rubber, alcohol and special lubricating oils, all synthetic.

H. W. FISHER

G. H. B. DAVIS

Esso Researchers Shift as Davis Goes to Market Group

Garland H. B. Davis, director of the research division of Standard Oil Development Company's Esso Laboratories, has been appointed to the marketing specialists group of Standard Oil Company (New Jersey), it was an-Company (New Jersey). He will be in charge of sales research and engineering.

E. Duer Reeves succeeds Davis as research division director, and Dr. F. L. Miller becomes associate director.

Davis joined Standard Oil Development Company in 1927 and was made director of the research division in 1941. A graduate of the University of Kentucky, he did post-graduate work at the Universities of Chicago and Ilinois, and attended Massachusetts Institute of Technology from 1923 to 1927.

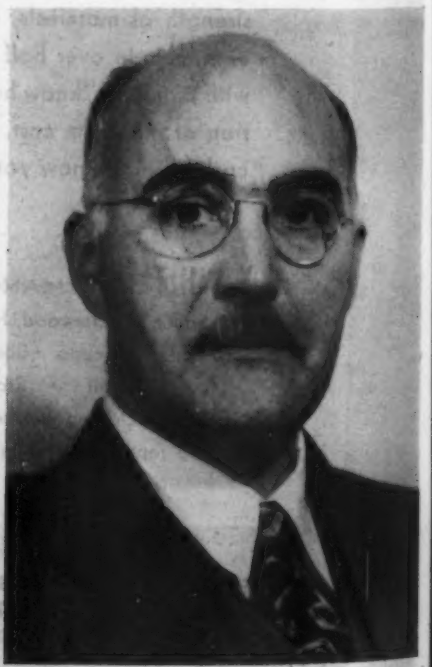
Reeves was graduated at Williams College in 1930 and took post-graduate work at Princeton University. He joined Standard Oil Company (New Jersey) as an engineer at Baton Rouge in 1931. In 1937 he was transferred to the research division of Esso Laboratories at Bayway, and became assistant director of the research division in 1944.

Dr. Carl O. Tongberg and Dr. Stewart C. Fulton were named assistant directors in the research division. A. J. Blackwood, presently an assistant director, continues in that capacity.

DR. C. O. TONGBERG

E. D. REEVES

DR. F. L. MILLER



DR. S. C. FULTON

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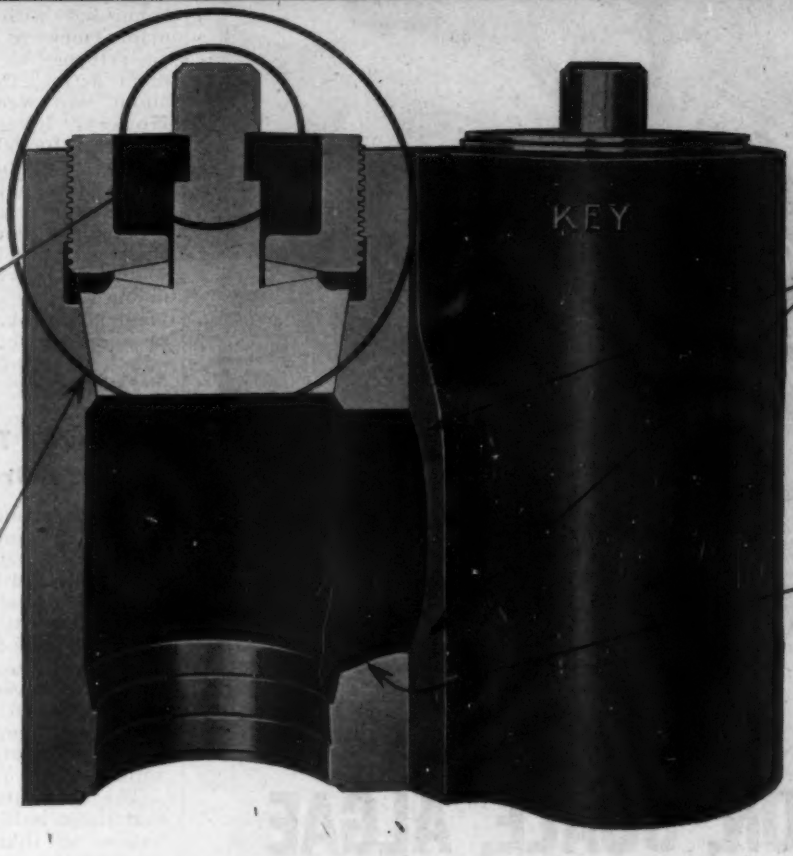

Positive, strong, simple, and safe pulling feature. Plug pulling tools and their use described in special bulletin.

Strongest closure assembly providing uniform distribution of installation stresses.

Reinforced cross-over port to give uniform stress and maximum corrosion allowance.

Reinforced streamlined cross-over port to minimize pressure drop and turbulence.

The improved Key 7000 was designed and developed after extensive research on all types of return bend fitting designs at the University of Michigan. Careful and elaborate study was also made of refinery furnace operating conditions and a thorough investigation of installation and maintenance procedures was conducted. The result of this complete research is incorporated in the advantages of the improved Key 7000 Type Fitting.

Write for bulletin giving complete details and specifications so that you can see for yourself how this one fitting will meet *all* your needs.

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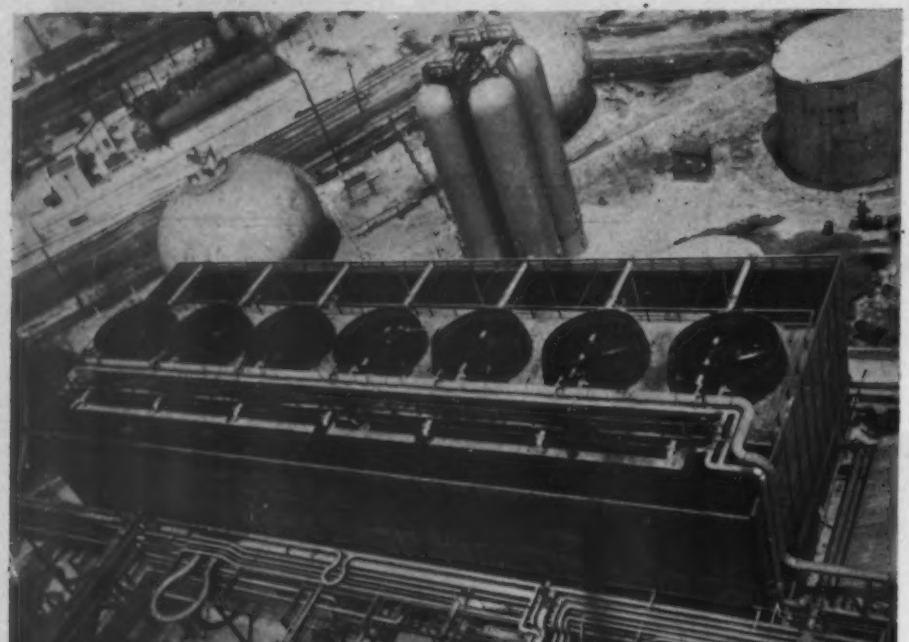

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PAW Takes Over Cities Service at Lake Charles

Operation of Cities Service Refining Corporation's refinery at Lake Charles, Louisiana, was taken over under executive order by Petroleum Administrator Harold L. Ickes on April 17, to culminate a shut-down which followed an unauthorized strike. A group of workers had walked out in a protest of an increase in rent in a housing project not connected with or influenced by the management of the refinery. The workers returned to work after the government action, the strike having caused about two weeks loss of production. However, Ickes will remain nominally in charge for 60 days.

The Lake Charles plant is one of the larger units built during the war to supply aviation gasoline, and also includes a butadiene plant which supplies an associated synthetic-rubber operation.

The strike was not authorized by the union which has the bargaining agreement at the plant, and it was intimated in some quarters that the workers who struck were influenced by a rival labor faction.

Improved Test Methods for Bearing Greases Issued

A joint committee of the Annular Bearing Engineers Committee and of the National Lubricating Grease Institute has issued three bulletins which describe in detail certain test methods and equipment for performance evaluation of anti-friction-bearing greases. Copies of these bulletins may be obtained from Annular Bearing Engineers Committee, 60 East 42nd Street, New York, or from National Lubricating Grease Institute, 164 Chandler Street, Buffalo, New York.

The committee considers it important that these bulletins receive wide distribution so that the methods may be checked by as many laboratories as possible.

Bulletins 1 and 5 are priced at $1, and Bulletin 4 at 50 cents.

Technical Bulletin No. 1 contains detailed information on the S. O. D. pressure-viscosimeter which is used to determine grease viscosities over a range of temperatures and rates of shear. This information is included to encourage further work on grease viscosity measurement, because potentially such work may yield data of a more fundamental nature than is obtainable by the use of torque test devices. This bulletin also describes recommended practices for accurate measurement of low temperatures. Measurement of extremely low temperatures involves technical difficulties not normally encountered. Since an error in temperature measurement of only a few degrees may involve very large errors in test results, a precise technique is essential.

Technical Bulletin No. 4 describes an improved procedure for the Norma-Hoffman Bomb Oxidation Test. While this test method has been in use for some years, it was never adequately standardized as to details of operation and procedure with the result that reproducibility between different laboratories has been poor. The revised method proposed is a summation of the experiences gained from an extensive study by the joint committee, and work to date indicates it is more accurate.

precise and reproducible. This test is designed to provide information which will permit predicting the behavior of greases in bearings in storage or in bearings contained in equipment, electric motors, instruments, etc. under storage conditions.

Technical Bulletin No. 5 describes a new test apparatus and procedure for evaluation of anti-friction bearing greases for high temperature service conditions. Aircraft accessories and equipment, in particular, contain bearings which operate at speeds as high as 10,000 rpm and at temperatures as high as 300°F. Since much of such equipment can only be re-lubricated at infrequent intervals, greases of exceptional properties are essential. Bulletin 5 proposes a test apparatus and operating procedure which is intended to provide information on the performance characteristics of greases under such conditions of high speed and high temperatures. It represents the first attempt to establish a method which can be used by all interested laboratories on a common basis.

Atlantic Rounds Out 75 Years Continuous Operation

The Atlantic Refining Company was 75 years old on April 29. No formal observance had been arranged because of the war.

During three-quarters of a century, the company pioneered a number of developments.

The company was incorporated in Pennsylvania in 1870. Its career began with construction of a small refinery at Point Breeze, Philadelphia, since expanded into one of the most modern refineries. In addition, it now operates another large refinery at Port Arthur, Texas, and its marketing area extends along the Atlantic Coast from New Hampshire to Florida and westward to Ohio.

Crude-oil production was begun in 1916 and the company currently produces more than half of the oil for its manufacturing requirements. Before the war the companys fleet of 23 tankers brought crude oil and products to its marketing centers, but this fleet was turned over to the government shortly after Pearl Harbor.

The Atlantic Refining Company last year completed construction of two large fluid-catalyst plants. The building of these two units, one at Philadelphia and the other at Port Arthur, completed a wartime building program of more than $22,000,000.

In the early years of the present century the company installed the first "tower" stills at its Philadelphia refinery.

In 1915, the company built the first gasoline service station in the East.

The Atlantic Refining Company made the first Allied aviation combat gasoline in World War I to surpass Germany's plane fuel. It remained the only refiner supplying fighting gas of this quality, and it delivered approximately 50 percent of all the aviation fuel sent overseas while America was at war.

In 1926, the company placed in operation the first pipe stills capable of producing multiple streams of products from a single tower.

The first deep-sea, all-welded, self-propelled ship launched was an Atlantic tanker, built in 1930.

This work leaves NO margin for error. The mud pump manifold above will go to jungle heart in a far land thousands of miles from point of manufacture. Should it function imperfectly operations would be held up for six irreplaceable months . . . Jobs like this are made for Associated. It is a privilege to handle so many of such critical character.

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SCIENCE AND TECHNOLOGY ABSTRACTS

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Traver Road, Ann Arbor, Michigan
under supervision of

DR. E. H. LESLIE and DR. H. B. COATS

The abstracts here presented are selected from the current literature of science and technology to afford reference to fundamental information not easily available to all readers. Abstracts of articles appearing in readily obtainable trade journals are not included.

Photostat copies of original articles will be supplied at cost by The Leslie Laboratories. Complete or limited bibliographies covering special topics by title, by abstracts, or in complete manuscript, will also be prepared and furnished at reasonable cost by the Laboratories.

Fundamental Physical and Chemical Data

Composition of Vapors from Boiling Binary Solutions. D. F. Othmer and R. F. Benenati. *Ind. & Eng. Chem.* **37** (1945) pp. 299-303.

Methods previously described have been utilized to determine the compositions of vapors resulting from boiling solutions of binary liquids (vapor-liquid equilibrium data). Three binary systems were studied at atmospheric and subatmospheric pressures. In each case water is one component and the second components were acetone, methanol, and methyl ethyl ketone. The data are correlated with one another and with published values by logarithmic plots; these plots are particularly applicable for evaluating and correlating data for different temperatures or pressures. Other data at atmospheric pressure are presented for several binary systems, one component of which is acetic acid. The data are presented in eight tables and eight figures, and a bibliography of eight references is included.

Effect of Pressure on the Viscosity of C_6H_6. W. A. Felsing and F. Blankenship. *Proc. Okla. Acad. Sci.* **24** (1944) pp. 90-91.

The authors describe an apparatus for measuring viscosity by the oscillating-disk method, at pressures up to 2700 lb./sq. in. and at temperatures of 30° and 50° C. Increasing the pressure from 15 lbs. to 1900 lb./sq. in. increases the coefficient of viscosity at 30° four times. At 50° a two-fold increase was observed showing from 1500 to 2700 lb./sq. in. pressure.

Predicting Viscosity of Gases at High Pressure. E. W. Comings and B. J. Mayland. *Chem. & Met. Engr.* **52**, No. 3 (1945) pp. 115-16.

When reliable data on the viscosity of gases at high pressures are not available, a sufficient degree of accuracy can usually be obtained for design purposes through the use of a new chart developed by the authors. To employ the chart in predicting the viscosity at some elevated pressure it is necessary only to know the critical pressure and temperature of the gas, plus the viscosity at atmospheric pressure. In developing the method in charts the authors reviewed the data on the viscosity of gases at high pressure and selected those that were neither obviously in error nor questionable. Additional high pressure gas viscosity measurements were made on methane, ethylene, and propane. These were made in a glass capillary Rankine viscometer housed in a steel bomb. The viscometer gave direct determination of the viscosity and did not depend on calibration with gases of known viscosity. However, measurements were made on carbon dioxide for comparison with the data of Phillips and Stakelbeck. The authors estimate that the uncertainty of the viscosity measurements is not more than 1 or 2 percent. A detailed account of the experimental work and the preparation of the correlation are given in the recent University of Illinois Engineering Experiment Station Bulletin Series No. 354, "The Viscosity of Gases at High Pressures."

A Relation Between Viscosity and Refractive Index. R. T. Lagemann. *Jour. Amer. Chem. Soc.* **67** (1945) pp. 498-99.

During an attempt to estimate the viscosity of higher members of some homologous series, it was noted that the viscosity and the refractive index for liquids are functionally related. A linear relation is found to hold for every homologous series if the molecular refraction R is plotted against the viscosity constant I, which constant is defined as

$$I = \frac{M}{d}(\log_{10}(\log_{10} n) + 2.9)$$

where n is the viscosity in millipoises. A table is given showing the constants a and b as calculated for several series of compounds on the assumption that $I = aR + b$. It is evident from the table that the slopes are nearly identical for all series of compounds but that the intercepts vary. That linear equations represent the relations very well may be deduced from the fact that the use of the constants as given in the table allows calculation of the values of I averaging within ⅓ of 1 percent of the experimental values. As a consequence, if the density and molecular weight of a liquid belonging to any of the series are known, the viscosity can be calculated from the refractive index or the refractive index from the viscosity.

Chemicals Wanted

The National Registry of Rare Chemicals, Armour Research Foundation, 33rd, Federal and Dearborn Streets, Chicago 16, Illinois, has received urgent requests for the chemicals listed below. If anyone has one or more, even if only in one gram quantities, please inform the Registry.

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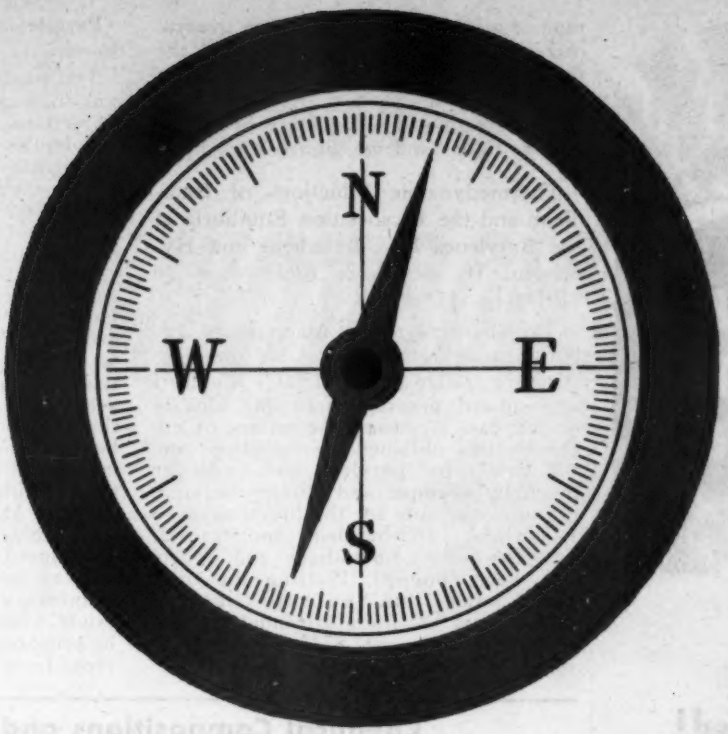
3-Amino-4-nitrotoluene
Hexene-1
Hexene-2
3,3-Dimethyl butene-1
2,3-Dimethyl butene-2
2-Methyl pentene-1
2-Methyl pentene-2
3-Methyl pentene-2
Cyclobutane
Cycloheptane
Cycloheptene
Cyclo octane
Cycloheptadecanone
2- or 4-Cyclohexylbenzoic acid
Dimethyl succinate
2,6-Dinitro toluene
unsym Dimethyl ethylene diamine
Ethyl orthocarbonate
Oxetone

Heats of Combustion of Eight Normal Paraffin Hydrocarbons in the Liquid State. E. J. Prosen and F. D. Rossini. *J. Res. Natl. Bur. Standards* **33** (1944) pp. 225-272.

The heats of combustion of the normal paraffins from pentane to decane and for dodecane and hexadecane were determined. The results were recorded in terms of the international joule, which, divided by 4.1833 gave the equivalent in calories. The purity of the hydrocarbons was determined. One of the octane samples, as the maximum, had 0.008 mole fraction of impurity, largely an isomer that would affect the heat of combustion only very slightly. Values found were as follows, expressed in international kilojoules: n-pentane, 3508.56 ± 0.77; n-hexane, 4162.34 ± 0.83; n-heptane, 4816.24 ± 0.87; n-octane, 5469.82 ± 1.05; n-nonane, 6123.90 ± 1.12; n-decane, 6777.47 ± 1.52; n-dodecane, 8085.20 ± 1.65; n-hexadecane, 10699.1 ± 2.8.

The Volume of Mixing and the Thermodynamic Functions of Binary Mixtures. II. Benzene-Cyclohexane. S. E. Wood and A. E. Austin. *Jour. Amer. Chem. Soc.* **67** (1945) pp. 480-83.

The volume change on mixing benzene and cyclohexane at constant pressure has ben determined over the entire composition range from 15 to 75°. From this the excess change of the work content, energy, and entropy on mixing at constant volume over that of an ideal solution has been calculated. The vol-



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ume of mixing is positive and in general increases with the temperature and the excess entropy on mixing at constant volume is also positive over this temperature range. The data are presented in four tables and five figures.

Thermodynamic Functions of Butadiene and the Dissociation Equilibria of the Butylenes Into Butadiene and Hydrogen. H. ZEIZE. *Z. Elektrochem* **50** (1944) pp. 113-20.

The thermodynamic functions of 1,3-butadiene were calculated for the temperature range 298.1°-1500° K. at 1 atmospheric pressure, assuming ideality of the gas. By using the values of enthalpy thus obtained for butadiene and the values for butylene and hydrogen given by Giauque and Pitzer the equilibrium constants for the dissociation of 1-butylene, cis-2-butylene and trans-2-butylene into 1,3-butadiene and hydrogen were obtained. Plotting the theoretical values and the experimental values from the literature indicates that over the range 677-873° K. the free rotation form of butadiene exists.

Petroleum in England. C. A. P. SOUTHWELL. *Jour. Inst. Petr.* **31** (1945).

The production of petroleum in England that started in 1936 is described. Three hundred and eighty wells of varying depths have been drilled, covering the testing of forty-five structural areas; of these, 250 are producing wells. The total effort has so far resulted in the production of 2¼ million barrels of good-quality crude oil. The data are given on the specific gravity, distillation, and properties of a typical crude from Eakring No. 1 well. The crude is greenish-brown in color and is of mixed type. The gasoline distillates are mixed types with naphthenic characteristics predominating, and are interesting from the standpoint of the high-octane-number and non-knocking properties. The crude contains considerable wax, more than double that normally present in an average Mid-Continent crude. The sulphur content is low, and is normally distributed. The gasoline contains 0.01 percent sulphur. There is practically no elementary sulphur in solution in the crude. Lubricating oils of high grade can be prepared that compare favorably with those from Mid-Continent crude.

Chemical Compositions and Reactions

The Mechanism of the Hydrogen Fluoride Catalyzed Alkylation of Toluene by t-Butyl Chloride. W. H. PEARLSON AND J. H. SIMONS. *Jour. Amer. Chem. Soc.* **67** (1945) pp. 352-62.

An improved apparatus has permitted more precise measurements of the reaction of t-butyl chloride and toluene as catalyzed by hydrogen fluoride. The effect of four promoters, water, methanol, diethyl ether and hexamethylacetone, was studied. It was found that the rate of the reaction increased with the increasing concentration of the promoter, but that all promoters gave essentially the same effect at the same molar concentration. It was found necessary to modify the equations used by Sprauer and Simons to correlate the rate measurements in any one experiment, but their equations and theory are essentially confirmed. The amphoteric medium effect as it contributes to the mechanism of the reaction is substantiated by these measurements and by the effects of the promoters. It is also shown to be reasonable on the basis of other investigations. A one-step, condensed phase, catalyzed, and promoted reaction as the essential factor in the mechanism is shown to be satisfactory from kinetic considerations and reasonable from energy considerations. Mechanisms utilizing ions or free radicals as intermediates are shown to be untenable from energy considerations.

Preparation and Physical Constants of Acetylenic Compounds. A. L. HENNE AND K. W. GREENLEE. *Jour. Amer. Chem. Soc.* **67** (1945) pp. 484-85.

A series of acetylene derivatives was prepared from sodium acetylides in liquid ammonia. Modified experimental procedures resulted in securing markedly increased yields of good quality materials from which samples of high purity were prepared. Physical measurements were obtained that are either new, or else more precise than those in the literature. Among the substances for which physical constants are given are: 1-pentyne, 1-hexyne, 1-heptyne, 5-methyl-1-hexyne, 1-octyne, 2-butyne, 2-pentyne, 3-hexyne, 2-octyne, 3-octyne, 4-octyne, 1-6-heptadiyne, 1,8-nonadiyne, 2,7-nonadiyne. Attempts to prepare allyl-acetylenes failed. Both allyl chloride and allyl bromide reacted at once with sodium acetylide to give up to 93 percent of an orange colored unstable derivative that boiled with decomposition.

Surface Chemistry. Edited by F. R. Moulton, Amer. Assn. for the Advancement of Science, Smithsonian Institution Building, Washington, D. C., 1943. Price to members, $2.75; to others, $3.25.

The book is based on a symposium in commemoration of the twenty-fifth anniversary of Dr. W. D. Harkins' first publication in this field. The subject is of both theoretical and practical interest for the understanding of many technological problems and physiological processes. Fifteen leading authorities have contributed to the work. Among the contributions are those that deal with orientation, polarity, rate processes, and intermolecular attractions in and between surfaces. These are related to problems of friction and lubrication as well as to the nature of cohesion, adhesion, and catalysis.

The Future of Our Oil Supplies Assured by Technology. R. E. WILSON. *Mining and Metallurgy* **26** (1945) pp. 15-18.

The United States has approximately 15 percent of the world's land area, 7 percent of its population, and uses 65 to 70 percent of the world's vehicles and rubber. It produces and refines 65 to 70 percent of the world's petroleum. Five hundred thousand barrels per day of 100-octane gasoline are produced for our air forces out of a total of more than 800,000 barrels of all kinds of gasoline. Of this, approximately half is used in Europe, one quarter in this country and one quarter in the Far East. At the con-

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clusion of the war in Europe approximately 100,000 barrels per day of 80-octane gasoline and 200,000 barrels of 100-octane gasoline will be free for use elsewhere than Europe. The Pacific war will continue to demand undiminished supplies of heavy fuel for shipping. At the close of the European war less diesel fuel will be required. The subject of proven reserves is discussed and statistics given. The developments of technology and research have been such that our petroleum resources have in effect been multiplied many-fold.

Manufacture: Processes and Plant

Variable Heat-Transfer Rate Correction in Multipass Exchangers, Shell-Side Film Controlling. K. A. GARDNER. *Trans. A.S.M.E.* **67** (1945) pp. 31-38.

The author outlines a method for determining the effect of a varying heat-transfer rate on the mean temperature difference of multipass shell and tube exchangers in which the heat-transfer rate can be considered independent of the tube-fluid temperature, and as a function of the shell-fluid temperature only. Two cases are analyzed, one with the shell fluid entering at the stationary head end, and the other at the floating head end of the exchanger. Derivation of equations for these two cases is given in the appendix. A tabulation of correction factors for cross-flow and 1-2 multipass exchangers indicates that the results are the same regardless of the number of tube passes or the direction of flow of the shell fluid. Results are presented in tabular and graphical form, giving a correction factor that can be used to determine the true mean heat-transfer coefficient of temperature difference products.

Graphical Solution of Friction Loss Problems in Fluid Flow. A. E. KROLL. *Chem. & Met. Engr.* **52,** No. 3 (1945) pp. 110-11.

To eliminate the mathematical computations involved in the method ordinarily used to solve problems of pressure drop due to friction, the author has prepared three graphs that reduce the calculations to the simple multiplication of three factors. The accuracy of the method is believed to be well within the limits of practical operations. One chart gives the relationship between head loss due to friction, rate of flow, and size of pipe. The loss as read from this chart is correct only if the kinematic viscosity is 1.1 centistokes and the pipe is clean steel. The second chart gives a correction factor for viscosity, and the third chart a correction factor for pipe roughness.

Improved Fluid Process for Catalytic Cracking. E. V. MURPHREE, C. L. BROWN, E. J. GOHR, C. E. JAHNIG, H. Z. MARTIN AND C. W. TYSON. *Trans. Amer. Inst. Chem. Engrs.* **41** (1945) pp. 19-33.

The authors discuss the general engineering features of the improved Fluid process for catalytic cracking and consider the mechanics of its operation. The new "downflow" design is compared with the older "upflow" design. Dust recovery has been lessened, the degree of contact in the reactors can be set at will, and for several reasons investment and maintenance costs are lowered. A flowsheet of the Fluid catalyst cracking plant is presented and the operation is described. Catalyst flow, oil flow, air flow, catalyst storage, heat balance are discussed in some detail. Under design features the subjects covered are: instrumentation, slide valves, and catalyst recovery. At the time of writing the paper there were 36 Fluid cracking units in operation having a total nominal throughput of 400,000 barrels per day. Of these, all but four are of the new downflow design. All of these plants are operating to produce aviation base stock and olefins for production of aviation blending agents or butadiene. Some of the units are now scheduled for 8 months between shutdown periods. Erosion in the downflow plants has been of little importance. Figures on catalyst losses are presented. Tables are given showing the yield and qualities of the products made from paraffinic and naphthenic charging stock. It is noted that unleaded motor gasoline of essentially 100 CFR-R octane number quality can be readily made commercially in current design of Fluid catalyst plants.

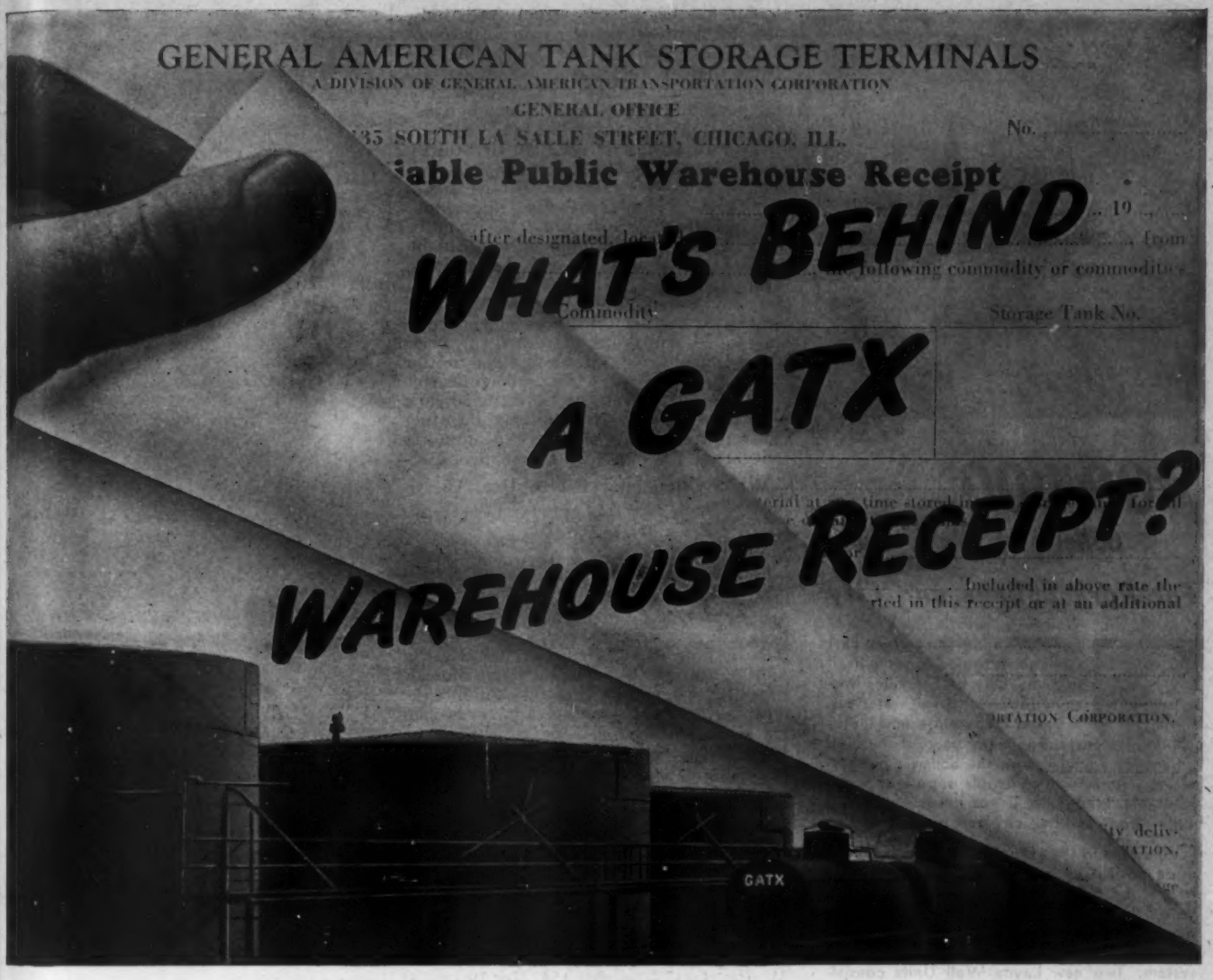
Measurement of Oil Depths. Measurement of Oil Depths Panel of Standardization Sub-Committee No. 1—Measurement and Sampling. *Jour. Inst. Petr.* **31** (1945) pp. 40-72.

Various methods commonly employed in the petroleum industry for the measurement of oil in tanks of various types are summarized. In practice, the choice of the method will be influenced by the nature of the material, the type and equipment of the container, and the accuracy required. The publication is a report of seven panels of a Sub-committee on Measurement and Sampling Standardization of the Institute of Petroleum. The subjects covered are: tank calibration, measurement of oil depths, sampling, temperature measurement, gravity measurement, units of measurement, calculations, and tables, and oil measurement apparatus. The methods described cover the following petroleum products: crude oil, liquefied hydrocarbon gases, natural gasoline, gasoline and motor fuels, light petroleum solvent, white spirit, kerosene, gas oil, diesel fuel, lubricating oil, electrical insulating oil, fuel oil, molten and liquid asphaltic bitumen and bituminous emulsion. The apparatus and procedures described apply to materials contained in the following: tanks of various types, ships and barges, rail and road tanks, and pipe lines.

Products: Properties and Utilization

Alcohol as an Engine Fuel. Natl. Bur. Standards Notes, *J. Franklin Inst.* **238** (1944) p. 454.

The Bureau of Standards has studied substitute fuels for possible use in various parts of the world where petroleum is not readily available. Alcohol of conventional grade and in mixtures with water containing as little as 35 percent



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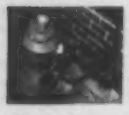

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alcohol has been used as fuel. As is indicated by the results, the horsepower of an engine is fixed by the supply of air rather than of fuel. Using 190 proof alcohol, a given engine will develop several percent more power than when using gasoline, although the heat of combustion of alcohol is less than two-thirds that of gasoline. The added horsepower results from the fact that more air is sent to the cylinder because the vaporization of the alcohol cools the air more than gasoline. Although engines can be operated on very lowproof alcohols, these fuels have several disadvantages; the requirement of fuel is so large that carburetor connections, fuel lines, pumps and tanks must be increased in size; large quantities of water collect in the crank case, and spark plugs become wet and fail to fire at low throttle. Spark settings must be changed and the fuel consumption, based on alcohol alone, is twice that for alcohol of high proof.

What Quenching Oil to Use. W. G. FORBES. *Iron Age* **154**, No. 5 (1944) pp. 50-51, 136.

The mineral oil best for quenching is a light oil distillate, from paraffin-base crude oil, of Saybolt viscosity of approximately 100 seconds at 100° F. The best oil temperature for most quenching is 75° to 120° F. Neutralization number should be checked from time to time to determine the rate of breakdown. Although some advantage is had by the addition of 3 to 5 percent of lard oil to the mineral oil, this appears less important than maintaining the oil at uniform temperature and providing means for circulation. Animal and fish oils decompose too rapidly when subjected to heat, and plant and vegetable oils oxidize too easily and also have drying properties. Mineral oils are superior to the animal and vegetable oils in stability.

What Quenching Oil Not to Use. G. W. PRESSELL. *Iron Age* **154**, No. 19 (1944) pp. 62-65.

The mineral oil stock used in making quenching oil must have many of the properties of a high-grade lubricating oil, such as oxidation-resistance, and be refined by a procedure eliminating light ends. Inhibitors and antioxidants preventing sludging and thickening of the oil during long service should be added. To give greater speed in quenching, the base oil should be treated by the addition of wetting agents that will cause the vapor sheath to collapse more quickly. Many tests are described that show the superiority of quenching oils treated in this manner over straight mineral quenching oil.

A New Experimental Approach to the Study of Boundary Lubrication. E. N. DACUS, F. F. COLEMAN AND L. C. ROESS. *J. Applied Physics* **15** (1944) pp. 813-24.

The term "boundary lubrication" refers to the condition in which the film of lubricant is too thin to prevent contact between the rubbing surfaces. The authors studied that phase of boundary lubrication in which no replacement or redistribution of the lubricant occurs. The capacity of a lubricant to maintain a low coefficient of friction under these conditions is called its "durability." A new apparatus was developed for the investigation of the durability of monolayers of polar lubricants. This apparatus is described in detail. It has

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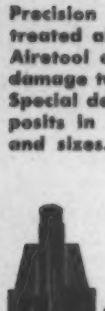

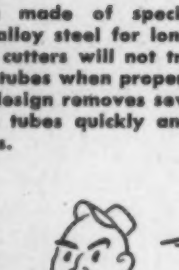

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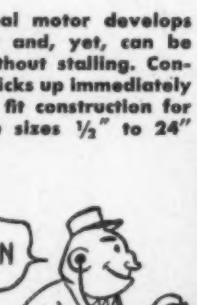

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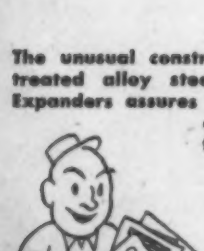

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been believed that a compact monomolecular layer of a polar lubricant deposited on a clean surface by smearing on an excess and then rubbing with a clean cloth produces a layer that cannot be removed by any amount of rubbing short of abrasion. The authors studied such films. They came to the conclusion that a rubbed-down monolayer of a polar lubricant is not so stable and permanent as has been supposed. The relative durability of a lubricant is obtained by measuring "absolute" durability of the standard lubricant and of the lubricant to be tested, then taking the ratio of the two. Barium stearate was chosen as the standard lubricant. Data are tabulated for various lubricants. Significant differences were found in the relative durability of polar compounds. In the case of the monocarboxylic acids, durability increases in proportion to the length of the molecule.

Method for Classification of Petroleum Waxes. A. KINSEL AND J. PHILLIPS. *Ind. & Eng. Chem., Anal. Ed.* **17** (1945) pp. 152-56.

Petroleum waxes have in the past been grouped into two broad classes—crystalline and amorphous. This terminology is now obsolete but is still used to some extent by the industry, although it is generally understood that truly amorphous waxes do not exist. The term "microcrystalline" has now been substituted for amorphous. The authors describe a simple test by the means of which the crystallinity of petroleum waxes can be measured in relative terms. The test involves determining the melting point of a wax and measuring the percent of contraction of a known volume of wax from 10° F. above to 50° F. below the melting point of the wax. With these data the degree of crystallinity (called the crystallinity index) of the wax can be calculated. The difference in crystalline structure of waxes and the action of pour-point depressants on waxes are clarified by this test. The procedure can be used as a substitute for or in conjunction with the U. S. Army specifications for cohesion at low and room temperatures. A bibliography of fifteen references is included.

Efficient and Versatile Laboratory Fractionation Column Assembly. F. TODD. *Ind. & Eng. Chem., Anal. Ed.* **17** (1945) pp. 175-81.

The author describes an efficient and versatile laboratory fractionation column that can be used for the fractionation of practically any liquid mixture in volume from 2 cc. to 5000 cc. and containing components that boil from room temperature to 752° F. with a fractionation efficiency equivalent to 30 to 50 plates. The fractionation efficiencies and large throughput capacities of the packings enable complex mixtures to be separated in a minimum of time. Mixtures with components whose boiling point differences are as little as 5.9° C. can be readily separated by fractionation. The newly developed staggered dual heating unit enables a packed or plate laboratory column to operate under essentially adiabatic conditions with complete visibility to all parts of the apparatus. By means of specially designed supports, the entire apparatus can be rapidly assembled or dismantled. A reflux regulator of 0.2 cc. holdup capacity is used. It can be set for reflux ratios from 1-1 to 100-1, or for total reflux or total product. An improved spiral pack-

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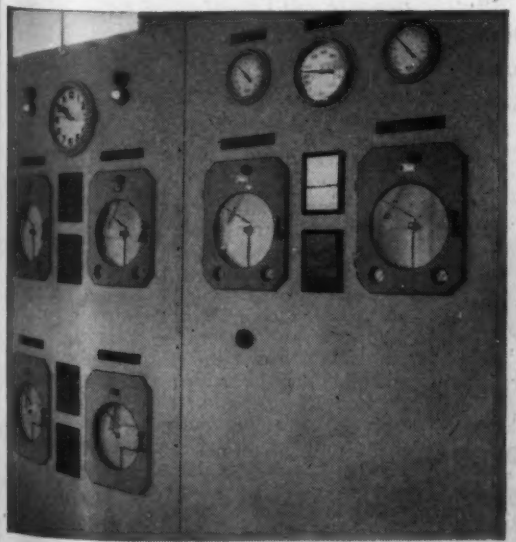

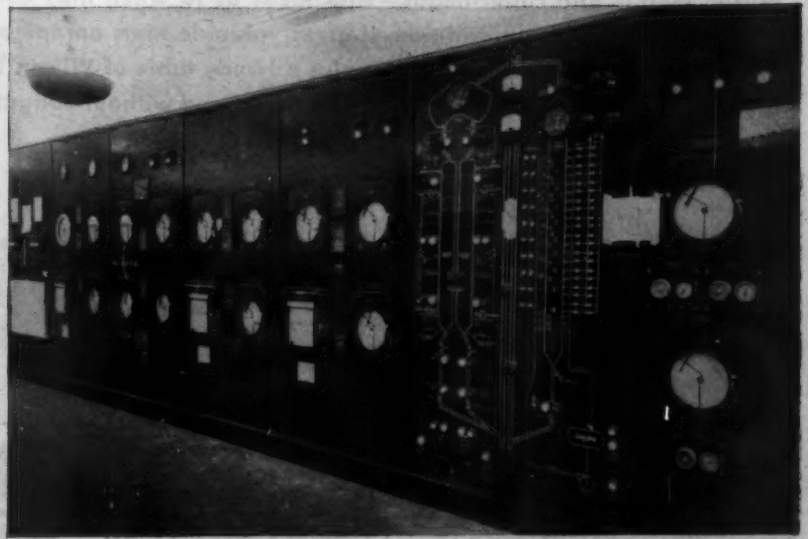

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scribed which the author found to be the most efficient of the many tested. The mechanical construction of the column and the various auxiliary apparatus is described in considerable detail. Typical distillation curves for several binary mixtures and for one 10-component mixture are presented. A bibliography of 69 references is included.

Packing Support for Laboratory Fractionating Columns. J. R. LONG. *Ind. & Eng. Chem. Anal. Ed.* 17 (1945) p. 197.

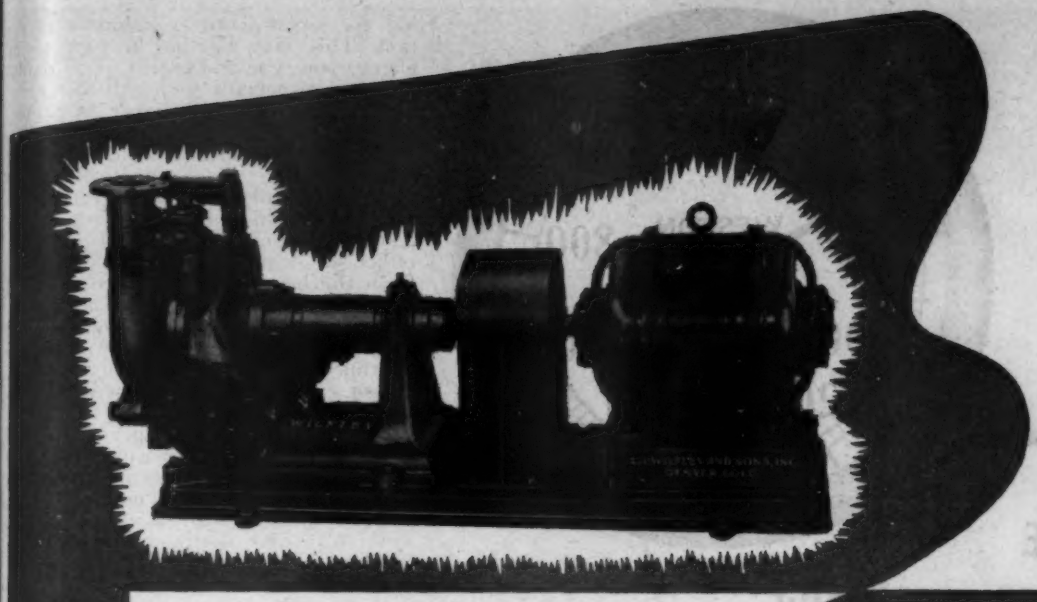
The author points out that various designs of supports for fractionating column packing have been described but that all have one or more disadvantages: flooding because of insufficient capacity, corrosion of construction materials, or ease of breaking. A support is described that eliminates these difficulties and it has the additional advantage that the rate of return of the liquid to the still pot is easily observed. Supports have been constructed for columns ranging in size from 7 to 52 mm. in diameter. Details of constructing the support are given, particularly those involved in the glass blowing technique.

Predicting Volume Increase of Perbunan Compounds in Petroleum Products. R. M. HOWLETT. *Ind. & Eng. Chem.* 37 (1945) pp. 223-25.

In the formulation of oil-resisting synthetic rubber stocks, it is frequently desirable to know what will be the approximate volume increase of the proposed compound in a certain immersion medium under specific test conditions. A study was accordingly made of the volume increase of Perbunan compounds immersed in various petroleum products. As a result of this work a method was developed for calculating the volume swell of a Perbunan compound when it is immersed in a given petroleum product under definite test conditions. The work of prediction or calculation of volume increase has been simplified by the construction of two graphs that can be used with experimentally determined constants of swell and extraction. Tables are given showing the volume increase of Perbunan compounds in two gasolines after 168 hours at 25° C., the polymer swell of Perbunan in petroleum products of various types, volume increase and extract coefficient values of Perbunan compounds after immersion in petroleum products, and the calculation of volume increase of Perbunan compounds containing extractable softener.

A Laboratory Machine for Investigating Corrosion of Bearings. S. K. TALLEY, R. G. LARSEN, AND W. A. WEBB. *Ind. & Eng. Chem., Anal. Ed.* **17** (1945) pp. 168-75.

A simple laboratory machine called the thrust bearing corrosion machine has been devised that simulates the more important mechanical factors leading to corrosion of bearings, and permits a study of factors that control the appearance and extent of bearing corrosion. Metallographic examination of corroded bearing sections indicates that the laboratory corrosion test specimens are nearly free of unwanted mechanical destruction and that corrosion penetration is more regular than in engine bearing specimens. Of the operating factors affecting bearing corrosion, temperature has been found to be especially impor-



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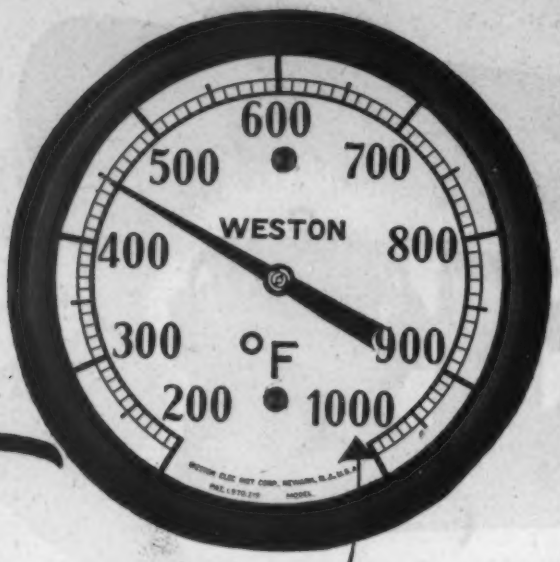

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ing for small-diameter columns is detant. This may be due in part to its effect upon type and extent of oil oxidation and, especially in highly detergent oils, upon the disappearance of protective films from the bearing surface. The machine is described in some detail and is illustrated diagrammatically and photographically. Data are given in tabular and graphical form showing the effect of temperature on corrosion, the effect of asphaltenes and detergents upon the bearing temperature rise, and upon coefficient of friction. The authors are of the opinion that any oil showing a corrosion loss in a twenty hour thrust bearing corrosion test greater than 1 mg. per sq. cm. should be regarded as potentially corrosive and those showing a corrosion loss of 5 mg. per sq. cm. or more are definitely corrosive. Losses of 0.3 mg. per sq. cm. or less are considered negligible. The authors note that they will be glad to furnish blueprints to those who may desire to construct the machine.

Book Review

The Story of the Diesel

Diesel Engine Manufacturers Association, One North LaSalle Street, Chicago 2, Illinois. 32 pages. Free.

A large postwar demand for diesel engines is building up, because engines are wearing out at a faster-than-normal rate, due to overtime work necessitated by the war effort. Practically all diesel-engine builders have been 100 percent in war work since the war started, they have not been in position to meet civilian demands.

These and many other facts about the industry are pointed out in "The Story of the Diesel," a booklet which in non-technical style it discusses the diesel's postwar future, its present fields of application, and advantages over other types of power. The beginning and development of the industry are also covered.

A chart depicts the industry's growth in horsepower-output from 1937 to 1944. In 1937 a production of barely 2,000,000 horsepower was recorded. This had leaped to 35,000,000 for last year.

A section describing opportunities for young men in the diesel-engine industry will be of special interest to returning war veterans, many of whom have had first-hand experience with diesels in the armed forces.

H. S. Chase Elected to Tide Water Directorate

H. S. Chase, vice president in charge of manufacturing, and Drew L. Hines, vice president in charge of transportation for Tide Water Associated Oil Company in the Eastern Division, have been elected directors of the company. Both have had more than 22 years continuous service with the organization.

Neblett and McKinney Advanced by Eastern States

Duncan Neblett has been elected a vice president of Eastern States Petroleum Company, Houston, and will continue his duties as secretary of the corporation. He joined the company in 1943 as assistant to the president.

Martial J. McKinney has been advanced from assistant treasurer to treasurer of the company.

Chicago Bridge & Iron Company installations are installed by our own experienced field crews.

DIGEST OF UNITED STATES PATENTS

On Desulfurization Issued in 1944

Compiled by HEINZ HEINEMANN

U.S.P. 2,338,371. Process for Sweetening Light Hydrocarbons. A. R. Workman to Cities Service Oil Company.

Cupric orthophosphate is unusually effective for sweetening sour oils in the absence of acids and halogen and when used in the presence of oxygen at a temperature of 100-200° F.

U.S.P. 2,338,579. Refining Mineral Oils. H. G. M. Fischer to Standard Oil Development Company.

Mercaptan compounds are removed from feed oils containing the same by utilizing a spent doctor solution from which precipitated lead sulfide and preferably from which the entire amount of lead has been removed.

U.S.P. 2,338,581. Catalytic Process. J. A. Guyer to Phillips Petroleum Company.

Regeneration of spent desulfurization catalysts is obtained by (1) heating in a furnace by combustion of a fuel in such a manner as to use up substantially all of the oxygen of the air introduced into the combustion zone, thus producing a hot flue gas which is substantially oxygen free or which contains less oxygen than is required for catalyst regeneration, (2) mixing with the hot flue gas sufficient air or other oxygen-containing gas to obtain the desired low oxygen content, (3) passing the gas over a deactivated catalyst to regenerate the catalyst, (4) heating a stream of reactants in the furnace by indirect heat exchange, and (5) passing the reactants over the catalyst for accomplishing desired conversions.

U.S.P. 2,338,585. Process of Sweetening Petroleum Distillates. M. C. K. Jones and R. C. Brandon to Standard Oil Development Company.

Certain organic substances, particularly high molecular-weight proteins which characteristically form musilaginous colloids with water, are used effectively in the washing step, to expedite the separation of metal sulfide to the last traces from a sweetened hydrocarbon oil. Gelatin or casein in amounts of 0.1-10.5 percent may be used.

U.S.P. 2,338,941. Process of Refining Mineral Oils. R. D. Howard to Petroleum Research Corporation.

Hot vapors of a sulfur-containing petroleum distillate are subjected to the conjoint action of small proportions of oxygen and water vapor and without adding any other active reagent, the resultant heavy reaction products are separated from the vapors while passing them in contact with reflux liquid comprising condensed components of such vapors. The vapors, while still hot, are then passed through a permeable mass comprising solid contact material containing oxidized metal, whereby sweetening is effected.

U.S.P. 2,339,889. Refining of Mineral Oils. B. R. Strickland to Standard Oil Development Company.

Feed oils containing undesirable constituents, such as sulfur-containing compounds, mercaptans, phenols and naphthenic acids are contacted with an alkaline metal alcoholate. The mixture is separated, the solvent distilled from the extraction phase, the resulting product diluted with water and steam stripped to remove mercaptans. The stripped product is reacted with carbon dioxide to liberate phenols, and the residue is acidified to separate naphthenic acids.

U.S.P. 2,340,157. Refining of Oil. R. B. Thacker to Sinclair Refining Company.

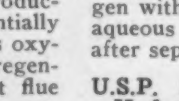
Undesirable sulfur compounds are removed from light petroleum hydrocarbons by intimately contacting the distillate at an elevated temperature and in the absence of oxygen with an aqeuous solution of caustic soda and litharge, separating the distillate from the aqueous solution, intimately contacting the separated distillate at an elevated temperature and in the presence of oxygen with a suspension of lead sulfide in aqueous caustic soda solution and thereafter separating the distillate.

U.S.P. 2,340,922. Desulphurization of Hydrocarbon Oils. R. D. Bent and C. A. Pines to The Atlantic Refining Company.

A desulfurization process is described which subjects hydrocarbon distillates in the vapor phase repeatedly to the action of desulfurization catalysts such as fuller's earth at 600-800° F. and 30-50 pounds pressure.

U.S.P. 2,341,329. Removal of Copper from Hydrocarbon Oils. R. J. Myers to Resinous Products & Chemical Company.

Copper compounds are removed from hydrocarbon oils by contacting them with particles of a resinous composition which is insoluble in water and hydrocarbon oils, which contains multiple



—NH—C—NH— linkages and which

is formed by reaction of formaldehyde and at least one resin from a compound selected from the class consisting of carbarnides and triazines.

U.S.P. 2,341,917. Method of Removing Mercaptans from Hydrocarbon Liquids. L. M. Henderson and G. W. Ayers to The Pure Oil Company.

The results obtained in removing mercaptans by washing hydrocarbon liquids with caustic alkali solution either alone or containing solubility promoters can be considerably improved upon by adding to the caustic alkali solution poly-hydroxy-diphenyls which are of themselves good solubility promoters and which have the further ability to act as solventizers for solubility promoters whose solubility in alkali solutions is low.

U.S.P. 2,343,794. Refining of Mineral Oils. H. C. Paulsen to Standard Oil Development Company.

Mercaptans are removed from an oil by contacting it with a treating agent comprising an alkali metal hydroxide solution and morpholine.

U.S.P. 2,343,841. Removal of Aromatics Sulfur or Unsaturates from Hydrocarbons. R. E. Burk to The Standard Oil Company (Ohio).

Sulfur, aromatics or unsaturates are removed from petroleum or other hydrocarbons by means of a "solvent catalyst." The hydrocarbons are treated with liquid hydrogen fluoride containing a minor proportion of boron trifluoride under a pressure to maintain the HF in the liquid phase. Temperatures of 32-110° F. are employed and 5-150 volume percent of liquid HF plus enough BF_3 to provide a partial pressure of 25-200 pounds are used. A fluoride complex is formed and removed by gravity separation.

U.S.P. 2,344,418. Process for The Removal of Undesirable Sulfur Compounds from Petroleum Oil. J. R. Schonberg to Standard Oil Development Company.

A process for removal of undesirable sulfur compounds from petroleum hydrocarbons boiling in the motor-fuel range under conditions to retain the major portion of the unsaturated constituents in the treated oil is described. The oil is treated at a temperature in excess of 65° F. with a mixture comprising sulfuric acid and a liquefied normally gaseous hydrocarbon under conditions to vaporize the liquefied hydrocarbon so that it acts as a refrigerant and removes the heat of reaction as it is formed, so that temperatures in excess of 70° F. are avoided and side reactions prevented.

U.S.P. 2,344,910. Method of Sweetening Hydrocarbon Oils. G. S. Windle to Standard Oil Company of California.

The process of the invention consists in blending oil which has been sweetened by the lead sulfide method or by the doctor and sulfur method, or by other chemically analogous methods with a regulated quantity of sour oil which has been contacted with doctor solution. After a period of time which may be 8 hours or more, the blend will be found to be sweet and to have attained a high quality with respect to color stability, inhibitor response, etc.

U.S.P. 2,345,449. Treatment of Hydrocarbon Oils. E. R. Birkheimer to The Atlantic Refining Company.

Hydrocarbon oils are desulfurized by contacting them with 35-50 percent of an alkali metal hydroxide and from 2-10 percent of a lower aliphatic alcohol and separating said solution from said oil. The presence of alcohol prevents solidi-

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fication of the alkali metal hydroxide solution when contacted with sulfur-bearing hydrocarbons.

U.S.P. 2,346,497. Solutizer Process. L. L. Lovell, A. E. Martin and F. W. Bell to Shell Development Company.

In a solutizer process the sour, H_2S-free, hydrocarbons are distilled and immediately thereafter and without allowing contact with air, the distillate which is free from oxygen and oxygen gum is extracted. Emulsification troubles are thus avoided.

U.S.P. 2,348,543. Treatment of Hydrocarbons. H. R. Johnson.

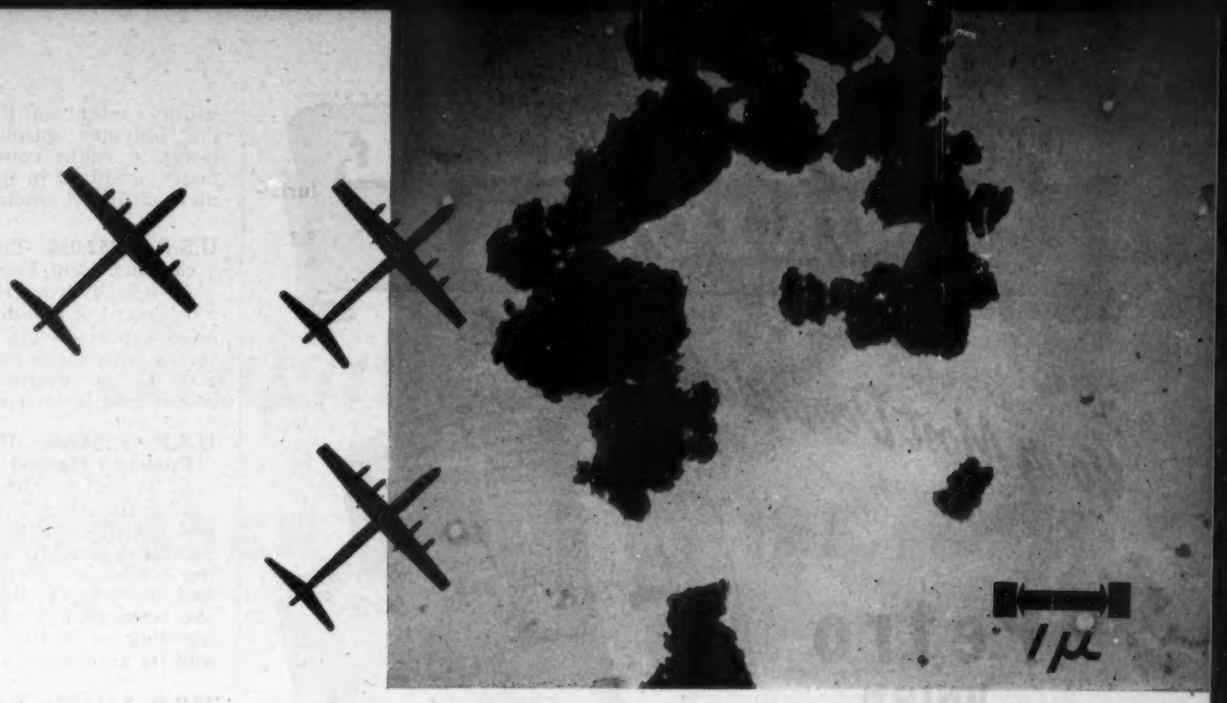
Hydrocarbon oils which can be vaporized without substantial decomposition are subjected to the action of chalk at a temperature of 500-1200° F. Pressures up to 100 pounds are employed. The contact time is regulated so as to prevent or minimize cracking. The sulfur content of the oils is reduced by such treatment.

U.S.P. 2,348,623. Refining Mineral Oils. A. P. Hewlett and P. C. Paulsen to Standard Oil Development Company.

An operation utilizing a doctor solution is described in which an overall sulfur reduction of the oil is secured. The addition of free sulfur is also eliminated. The oil is contacted with a doctor solution containing dissolved therein a solvent enhancing agent under conditions to convert the mercaptans to soluble lead mercaptides. The lead mercaptides are rendered substantially completely soluble in the spent doctor solution and are removed with the doctor solution rather than with the treated oil, which is contacted in a secondary stage with a filtering medium comprising clay which completely removes the remaining lead mercaptides dissolved in the oil. The solvent enhancing agent may be a quaternary ammonium base.

U.S.P. 2,351,154. Process for Treating Hydrocarbons. W. A. Schulze to Phillips Petroleum Company.

This discovery involves several coacting steps which may be briefly described as follows: (1) A crude oil is heated under pressure and flashed under such conditions that the temperature of the vapors leaving the tower is in the range of 600-800° F., the vaporizable constituents at said temperatures thus being separated from the non-vaporizable material; (2) The aforementioned vapors, comprising hydrocarbons in the range of gasoline, naphthas and gasoils are then passed over a desulfurizing contact catalyst which decomposes a great proportion of the sulfur compounds into hydrogen sulfide without any substantial decomposition of the hydrocarbons; (3) The treated vapors are fractionated to remove the hydrogen sulfide and, if desired, the straight-run gasoline fraction; (4) The hydrogen sulfide-free naphtha and gas oil are treated in the vapor form over contact catalysts of the bauxite type of temperatures in the range of 800-1050° F. to convert the hydrocarbons boiling above the gasoline range into lower-boiling compounds. Additional steps which may be included are the catalytic polymerization of the light and saturated hydrocarbons, primarily propylene and butylenes, and of finally blending these various compounds of high anti-knock characteristics and low sulfur content into improved motor fuel. Due to the low



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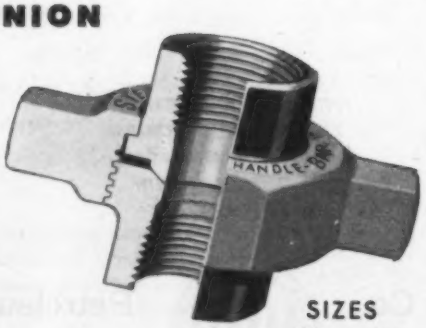

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sulfur content of the cracking stocks, the polymer gasoline will be much lower in sulfur content than that normally produced in the refinery charging undesulfurized stocks.

U.S.P. 2,352,059. Treatment of Hydrocarbons. Paul Woog.

A light hydrocarbon containing from 5-6 percent of an added sulfurized schist oil is vaporized and the vapors are contacted with a reforming catalyst at 300-500° C. A desulfurized and reformed motor fuel is recovered.

U.S.P. 2,354,646. High Octane Motor Fuel and Method of Producing Same. R. T. Bell to The Pure Oil Company.

The tricarbonyl mercaptides of iron and cobalt have the property of being soluble in gasoline and inhibiting knocking tendencies thereof. They are stable and sweet to the doctor test. By adding the tetracabonyl of metals to the sour gasoline at 90-100° C, it is sweetened and its anti-knock rating is improved.

U.S.P. 2,354,974. Regeneration of Spent Treating Solutions. A. E. Harnsberger to The Pure Oil Company.

Part of the steam required for stripping spent solutions is supplied by stripping under conditions to vaporize a portion of the stripped solution to supply steam. A portion of the steam used is condensed and used as a reflux for contacting overhead vapors in the stripping zone.

U.S.P. 2,355,147. Process for The Treatment of Hydrocarbon Gases. S. S. Chazanow to Phillips Petroleum Company.

Hydrogen sulfide is removed from hydrocarbon gas by absorbing it in an alkaline reacting aqeuous solution, capable of fixing hydrogen sulfide at low temperatures and disengaging it at elevated temperatures. The alkaline solution containing hydrogen sulfide is heated and an inert gas passed through to assist in the removal of hydrogen sulfide. The inert gas containing hydrogen sulfide is dried and passed to a hydrogen sulfide oxidation step, where the hydrogen sulfide is converted to sulfur and water. The inert gas is recycled.

U.S.P. 2,355,366. Process for Catalytically Desulphurizing Hydrocarbon Oil. M. W. Conn to Phillips Petroleum Company.

A cracking stock which is adapted to yield upon cracking hydrocarbons in the gasoline range and which is objectionable high in sulfur is first preheated and vaporized and then passed in admixture with from about 10-50 percent by volume of a mixture of hydrogen and other fixed gases consisting of C_4 and lighter paraffins and olefins over a desulfurization catalyst at a temperature of 500-800° F. The hydrogen sulfide formed is then removed from the stream.

U.S.P. 2,356,047. Refining Mineral Oils. A. J. Schmidl and M. Wiggen to Standard Oil Development Company.

In a doctor sweetening process the improvement is claimed which comprises in sequence the steps of intimately contacting one volume of the mercaptan bearing oil with more than half volume of alkali sodium plumbite reagent containing soluble lead in excess of 0.08 pounds per gallon to convert the mercaptans predominantly to basic lead mercaptides, separating the sodium

...again three more

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plumbite reagent from the leaded oil with a carefully controlled amount of sulfur slightly in excess of that theoretically required to precipitate lead sulfide and convert the lead mercaptides to organic disulfides, and separating the sweetened oil from the lead sulfide.

U.S.P. 2,356,980. Toluene Sweetening. G. F. de Ridder to Shell Development Company.

Sweetening of sour aromatic hydrocarbons can be achieved easily and without substantial loss if the sulfuric acid used for the treatment is thoroughly distributed throughout the hydrocarbon liquid by mechanical means and simultaneously a small, controlled amount of air is suspended in the liquid together with the acid. This amount of air is substantially less than the stoichiometrical amount required to convert all mercaptans to disulfides and is preferably ⅛ to ½ of this amount.

U.S.P. 2,357,121. Process for Desulfurizing Hydrocarbon Distillate. L. L. Lovell to Shell Development Company.

A continuous process for desulfurizing a normally liquid hydrocarbon distillate containing organic sulfur compounds is described which comprises contacting said distillate in the vapor form at a temperature below that of incipient cracking with a petroleum decolorizing adsorbent whereby a treated distillate vapor is produced which contains hydrogen sulfide, passing said resulting vapors over copper oxide to remove the hydrogen sulfide, dividing the resulting vapors into two unequal portions, recycling the larger of them to recontact the adsorbent along with more of the distillate, and withdrawing the smaller portion as a desulfurized product.

U.S.P. 2,357,559. Method of Sweetening Sour Gas and Preventing Corrosion of Oil Producing Wells. T. O. Smith To Odessa Chemical & Equipment Company.

A amount of aqua ammonia containing a solution (substantially 10 percent) of sulphonated fatty acid (vegetable or animal) is poured into the producing well between the casing and tubing. This acts to produce a thin protective film on the outer surface of the tubing as the mixture flows downward within the well. Ultimately the mixture is picked up by the oil as it travels upward within the tubing and as a result a protective film is applied to the inner surface of the tubing thus constituting a corrosion inhibitor.

U.S.P. 2,359,218. Method of Sweetening Chlorinated Aliphatic Hydrocarbons. W. Hunt and G. M. Hebbard to The Dow Chemical Company.

The chlorinated hydrocarbon is vaporized, the vapors are admixed with hydrogen to form a vapor mixture containing between 0.5 and 10 percent by volume of hydrogen, passing the vapor mixture over a hydrogenation catalyst at a reaction temperature between about 150 and 225° C. and thereafter scrubbing the reduction product from the chlorinated hydrocarbon with an aqueous solution of an alkali.

U.S.P. 2,360,537. Methods of Removing Mercaptans from Hydrocarbon Oil. G.W. Ayers and L. M. Henderson to The Pure Oil Company.

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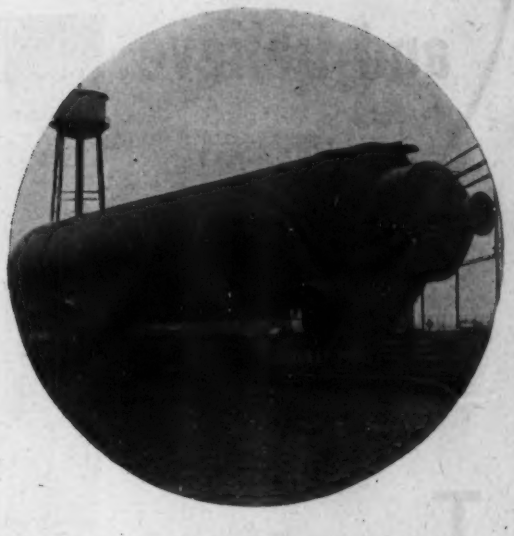
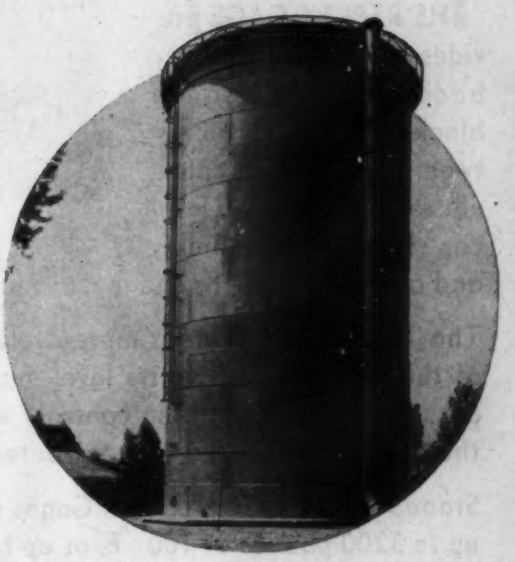




General American's Plate & Welding Division at Sharon, Pa. is *headquarters* for a diversified list of plate fabrication equipment.

If you are in the market for accumulators, crystalizers, dissolvers, heat exchangers, absorption towers, condensers, rotary kilns, digesters, storage tanks for oil, water, acid, etc., or any of the many types of plate fabrication—remember, General American is equipped to manufacture virtually anything made of carbon, stainless and alloy steels, Everdur, aluminum and other special alloys—either welded or riveted. General American offers, as well, complete X-ray facilities, heat-treating and stress-relieving furnaces and is in position to build and test all classes of welded vessels to API-ASME, ASME and other codes. Its unusually large manufacturing facilities are further supplemented by a staff of recognized engineers and scientists—complete research and development laboratories at both Sharon and Louisville, as well as a large field erection department for either foreign or domestic work. This all adds up to a combination which we believe to be unmatched elsewhere in America. Don't hesitate to call on us for any information that can be of assistance to you.

GENERAL AMERICAN

TRANSPORTATION GATX CORPORATION

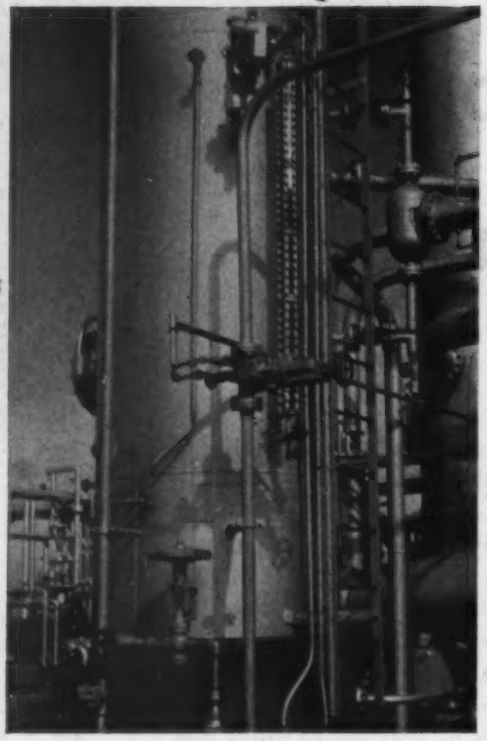
PROCESS EQUIPMENT DIVISION PLATE & WELDING DIVISION

General Sales Offices: **530 Graybar Bldg., New York 17, N. Y. •** ***Works:*** **Sharon, Pa., and Louisville, Ky.**

Sales Offices: **Louisville, Chicago, Sharon, Cleveland, Pittsburgh, St. Louis, Salt Lake City, San Francisco, Tampa, Washington, D. C.**

JERGUSON

Liquid Level Readings for the Eye to See and Believe



THE REFLEX GAGE provides maximum visibility because of the sharp black-white contrast between liquid and space above. The liquid level can be spotted quickly and at a distance. It's the most "readable" gage available.

The Transparent Gage is more useful if the condition or color of the liquid as well as its level must be checked. Light rays pass through the liquid in contrast with the reflex gage where the rays are reflected and refracted.

Standard JERGUSON Reflex Gages are designed for pressures up to 3200 pounds at 100° F. or up to 1200 pounds at 1000° F. Transparent Gages are designed for pressures up to 2000 pounds at 100° F. or up to 600 pounds at 1000° F. Each can be assembled in sections to meet any desired vertical range.

JERGUSON GAGE & VALVE CO.

87 FELLSWAY SOMERVILLE 45, MASS.

5-JV-3

other solutions containing solubility promoters can be enhanced by adding certain glycols. They are selected from the group consisting of triethylene glycol, propylene glycol and butylene glycol. Suitable solutions are prepared by mixing together in proper proportions water, alkali metal hydroxide, naphthenic acids, solventizer such as phenol or cresol and one or more glycols in amounts of 1-20 percent.

U.S.P. 2,361,008. Process for the Treatment of Hydrocarbons. E. Buddrus and H. L. Hays to Phillips Petroleum Company.

A portion of feed stock is withdrawn from a furnace at desulfurization temperature and subjected in the presence of a suitable catalyst such as bauxite impregnated with sodium hydroxide to desulfurization under reaction pressure and temperature conditions of the order of 0-50 pounds and 600-700° F.

U.S.P. 2,361,651. Desulphurizing Hydrocarbon Distillates. W. A. Proell and F. K. Ovitz to Standard Oil Company, (Indiana).

The process of sweetening and desulfurizing sour hydrocarbon distillates is claimed which comprises contacting the vapors of said distillates in the presence of oxygen with a catalyst composed of copper oxide in combination with at least an equal amount of an oxide, hydroxide or carbonate of a metal selected from the class consisting of magnesium, calcium and barium.

U.S.P. 2,362,296. Method for Removing Sulfur from Sulfur-bearing Hydrocarbons. E. V. Murphree, C. W. Tyson, D. L. Campbell and H. Z. Martin to Standard Oil Development Company.

Sulfur is removed from sulfur-bearing hydrocarbons by vapor-phase contact in a desulfurization zone with a powder of 200-400 mesh, consisting of copper, iron, nickel, antimony, bismuth, mercury, cadmium, and silver chlorides, sulfates, nitrates, iodides or oxides or the metals themselves or compounds which will form a sulfide upon contact with a hydrocarbon containing combined sulfur.

U.S.P. 2,362,669. Process for the Removal of Carbonyl Sulphide from Low Boiling Hydrocarbon Fluids. W. A. Schulze to Phillips Petroleum Company.

The complete removal of carbonyl sulphide from hydrocarbon fluids is described. Carbonyl sulphide is converted to a form insoluble in the hydrocarbon fluid and thus easily removable by contact with a solid reagent composed of an adsorbent carrier impregnated with active chemical ingredients. The reagent is prepared by impregnating fuller's earth or adsorbent clay type minerals with a lead solution such as sodium plumbite solution. The process is carried out at 30-100° F. and 50-500 pounds.

U.S.P. 2,364,390. Method for Removing Mercaptan Sulfur from Petroleum Distillate. J. G. Schaafsma to Socony-Vacuum Oil Company.

The mercaptan sulfur content of petroleum distillates of the gasoline type may be almost or completely removed by contacting the vaporized, mercaptan-containing distillate at high velocity and in the vapor phase with alkali-earth metal hydroxide. A temperature range of 800-900° F. is employed and granular

On Stream 186 Days

before being closed down for inspection

Another practical demonstration of why 60% of our contracts in six years has been repeat business.

Fluid Catalytic Cracking Unit—the Republic plant at Texas City. We engineered and constructed the first unit of this type to go on stream. (Basic design by Universal Oil Products Company.)

Engineering and Construction Division

JONES & LAUGHLIN SUPPLY COMPANY

TULSA, OKLAHOMA

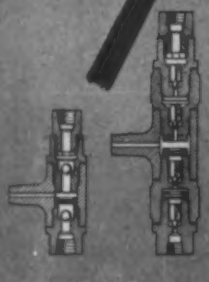
For *LABORATORY* and Production Service

HILLS-McCANNA *Type "U"* Proportioning Pumps

• The Type "U" pump was specially developed to meet requirements for high pressure, small capacity proportioning in experimental laboratories, liquid catalyst feeding, pilot plant work, acid and caustic injection, etc. It is available in 45 models with a range including 1.2 G.P.H. working against 4800 P.S.I. up to 31.2 G.P.H. at 190 P.S.I. The time-proved rack and pinion drive operates in a special oil filled housing. Rapid variation in volume is provided by a calibrated sleeve type adjustment.

This is only one of a complete line of proportioning pumps specially designed for a given type of service. They are the quality leaders. Write for CATALOG P-44 and outline your requirements.

HILLS-McCANNA COMPANY
2441 West Nelson Street • Chicago 18, Illinois



CHECK VALVES

Vertical composite check valves used with Type "U" pumps incorporate suction and discharge in the same body. Available in ball or cone types with single or double checks.

HILLS-McCANNA
Precision PROPORTIONING PUMPS
Proportioning Pumps — Force Feed Lubricators — Chemical Valves — Air & Water Valves — Marine Valves — Magnesium Alloy Castings

calcium oxide or hydroxide is a preferred agent.

U.S.P. 2,365,630. Production of Catalytically Cracked Gasoline. F. C. Fahnestock to Socony-Vacuum Oil Company.

A combined cracking and desulfurization process is described. Cracking takes place in the presence of a solid adsorptive catalyst and hydrogen sulfide and sulfur dioxide are separated from gasoline in a stepwise condensation of reaction products.

U.S.P. 2,365,993. Process for Refining Oils. F. A. Apgar to Sinclair Refining Company.

Undesirable sulfur compounds are removed from light distillates by contacting the distillate at 180-260° F. in the absence of oxygen with an aqueous suspension of cadmium hydroxide. The distillate is separated from the suspension and contacted with air at 180-260° F. under sufficient pressure to maintain the distillate in the liquid phase. Cadmium mercaptides formed are hydrolyzed and the suspension is regenerated by blowing with air near its boiling point.

Committee Will Make Patent Monopoly Study

Groundwork for possible patent legislation was seen in a letter from President Truman April 26, directing Secretary of Commerce Wallace to make an investigation to determine if patents are being "misused to support unlawful monopolies" in violation of the antitrust laws.

Wallace immediately appointed a committee to make the study. To serve, as suggested by the President, he invited Stabilization Director William H. Davies, Attorney General Francis Biddle, Charles F. Kettering, chairman of the National Patent Planning Commission, and Vannever Bush, director of the Office of Scientific Research and Development.

In his letter to the secretary, Truman suggested that Congress might be glad to have the results "of a full and objective study of the operation and effectiveness of the patent laws and their relation to the purposes of the antitrust laws and to the postwar economy, together with specific proposals for such legislation as may seem to be appropriate."

Thus far, the President commented, the several departments have made no concerted effort to formulate a policy upon this subject.

Furnace-Type Carbon Black Plant Is Being Erected

Continental Carbon Company is erecting a furnace-type carbon-black plant to handle 15,000,000 feet of gas daily, with anticipated recovery of 8 pounds of carbon black per 1000 feet, in the Sunray-Dumas field, Moore County, Texas Panhandle.

The unit is adjacent to the company's 70,000,000-cubic-foot channel black plant, which is supplied with residue gas from Shamrock Oil & Gas Corporation's McKee gasoline plant. Continental Carbon Company is owned by the latter. Continental Oil Company and R. I. Wishnick of New York.

REED

Quarter-turn Double Disc Gate

VALVES

100° F. BELOW ZERO

&

850° F. ABOVE ZERO

DEPENDABLE AND EASY TO OPERATE

Reed Valve discs are not subject to expansion or contraction of the Valve body and fluid temperatures may vary widely without affecting the action of the Valve. Reed Valves are giving dependable, trouble-free service in temperatures of more than 100° F. below zero to temperatures of 850° F. above zero.

Reed Valves are designed, constructed, and tested for operation under pressure and temperature conditions represented by the series designation.

Various trims and combinations are available and the Valve, when properly trimmed, will withstand the corrosive action of caustics, sour crude, sulfuric acid, etc.

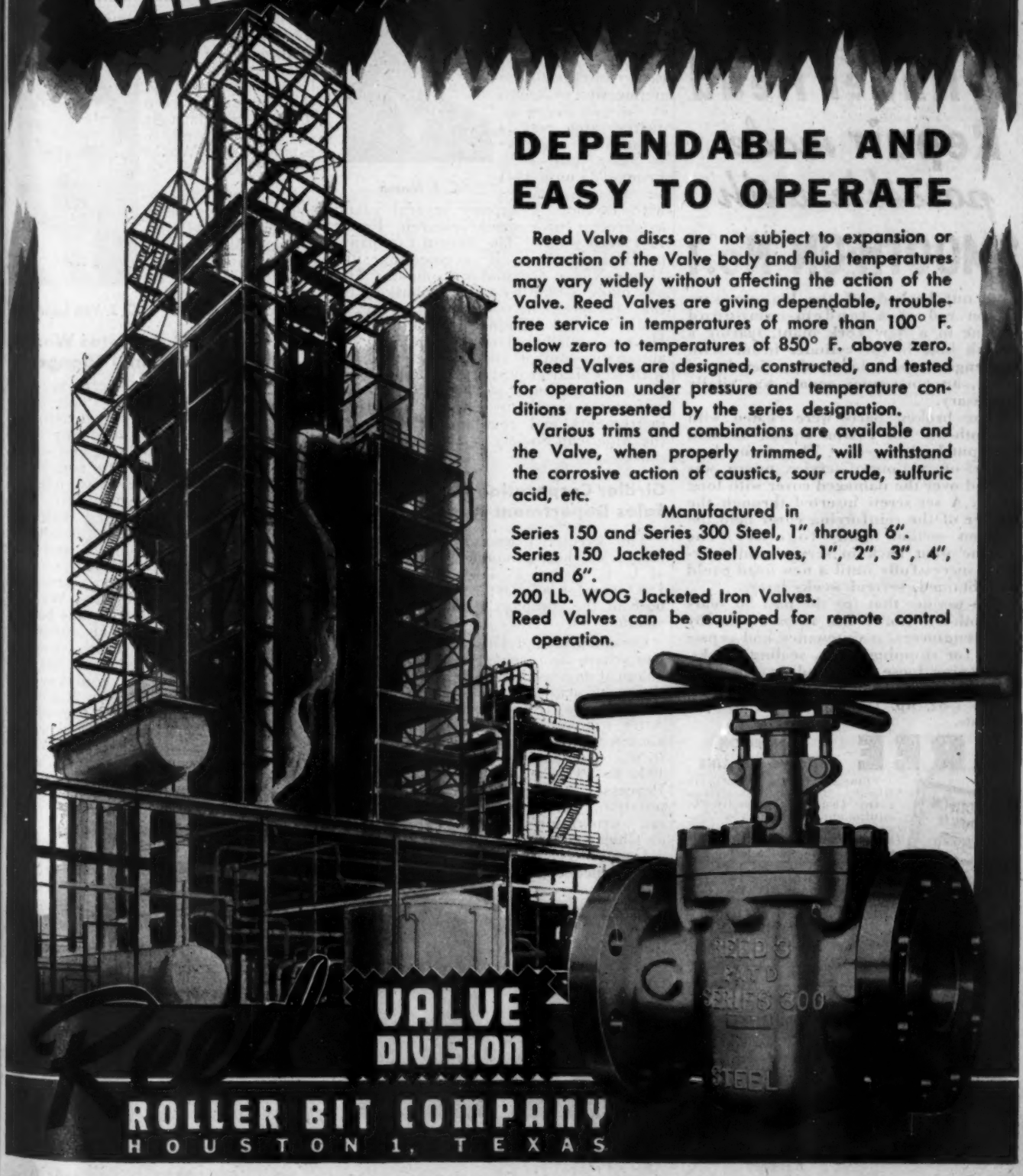
Manufactured in

Series 150 and Series 300 Steel, 1" through 6".

Series 150 Jacketed Steel Valves, 1", 2", 3", 4", and 6".

200 Lb. WOG Jacketed Iron Valves.

Reed Valves can be equipped for remote control operation.



Reed VALVE DIVISION

ROLLER BIT COMPANY

HOUSTON 1, TEXAS

Ingenious

Cylinder Head Repair *made possible with* **SMOOTH-ON No. 1**

A nut backed off the high-pressure piston rod of a tandem-compound engine in a New York plant, tearing a 3-inch hole in the cylinder head. With the engine's peak load only a few hours away, an emergency repair was vitally necessary.

The broken parts were coated with Smooth-On No. 1 Iron Repair Cement and put back together. The steam chest cover of an out-of-service pump was bolted over the damaged cover with long bolts. A set screw inserted through the center of the reinforcing cover held the broken section tightly together. The engine went back in service and operated successfully until a new head could be obtained, several weeks later.

No wonder that for the past 50 years Smooth-On No. 1 has been a standby with engineers, maintenance and repair men for stopping leaks, sealing cracks, tightening loose parts and fixtures. Get Smooth-On at your supply house. Sizes from 7-oz. up. If they haven't it, contact us.

FREE HANDBOOK SHOWS REPAIRS

Famous 40-page Smooth-On Repair Handbook describes many ingenious, short-cut equipment repairs. 170 diagrams. Clear directions. A book every engineer needs. Send coupon for your copy.

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Do it with **SMOOTH-ON**

About EQUIPMENT—SERVICE Suppliers

Mason Technical Director For The Bristol Company

C. E. Mason has been appointed technical director of The Bristol Company, Waterbury, Connecticut, and will be located at the main office.

C. E. Mason

Mason graduated from Marietta College in 1917 and after service with the Army Air Corps became interested in engineering problems in the petroleum industry and was a consulting engineer at Tulsa until 1925. From 1925 until 1941 he was associated with Foxboro Company several years as director of control research. From 1941 until joining The Bristol Company he was director of engineering for Mason-Nielan Regulator Company. He has made a number of contributions to the advancement of industrial automatic control design and engineering. He has contributed to the literature on automatic control and has been active with technical groups studying that subject, and currently is a member of the committee on theory of the industrial instruments and regulator division of the American Society of Mechanical Engineers.

Girdler Corporation Announces Sales Department Appointments

The Girdler Corporation, Louisville, Kentucky, has announced appointment of L. E. Osmer as sales manager, and J. D. Gordon as Eastern representative, both of the company's Gas Process Division.

Osmer attended University of Michigan where he received a degree in mechanical engineering in 1923, and started the same year as a cadet engineer with Semet Solvay Engineering Corporation. After four years as construction engineer with that company he transferred to the sales engineering staff, and from 1930 to 1943, when he joined the Gas Processes Division of The Girdler Corporation, was Semet Solvay Engineering Corporation's district representative at Chicago.

Gordon received his degree in chemical engineering from Georgia School of Technology in 1936, and joined the staff of Swann Chemical Company, Birmingham, Alabama, the same year. He has been with The Girdler Corporation's Gas Process Division since 1939. In New York his offices are at 150 Broadway.

L. E. Osmer

J. D. Gordon

Johnston & Jennings Company Makes Sales Staff Changes

The Johnston & Jennings Company, Cleveland, Ohio, has announced appointment of Murray Russell, formerly sales manager of the company's Oceco division, as manager of an office newly established at Washington, D. C.

C. J. Van Landeghem

C. J. Van Landeghem, formerly sales manager for Philip Carey Manufacturing Company, Cincinnati, is the new sales manager of the Oceco division.

Plant Rubber & Asbestos Works Announces Personnel Changes

Rubin Lewon has been appointed manager of research for Plant Rubber & Asbestos Works, San Francisco. During 11 years with the company he has served as research chemist and superintendent at Redwood City and Emeryville plants. In his new assignment he will be under direction of Dr. A. M. Erskine, recently appointed director of research and development for both The Paraffine Companies, Inc., and Plant Rubber and Asbestos Works.

Louis L. Collonge, who started with Plant Rubber and Asbestos Works in 1937 as a research chemist, has been appointed superintendent at Emeryville. E. Fred Karklin has been selected as superintendent at Redwood City. He also started with the company as a chemist, in 1939. Walter Rohde has been appointed manager of production control, with headquarters at San Francisco, and Victor Sagues will continue as superintendent of the San Francisco factory.

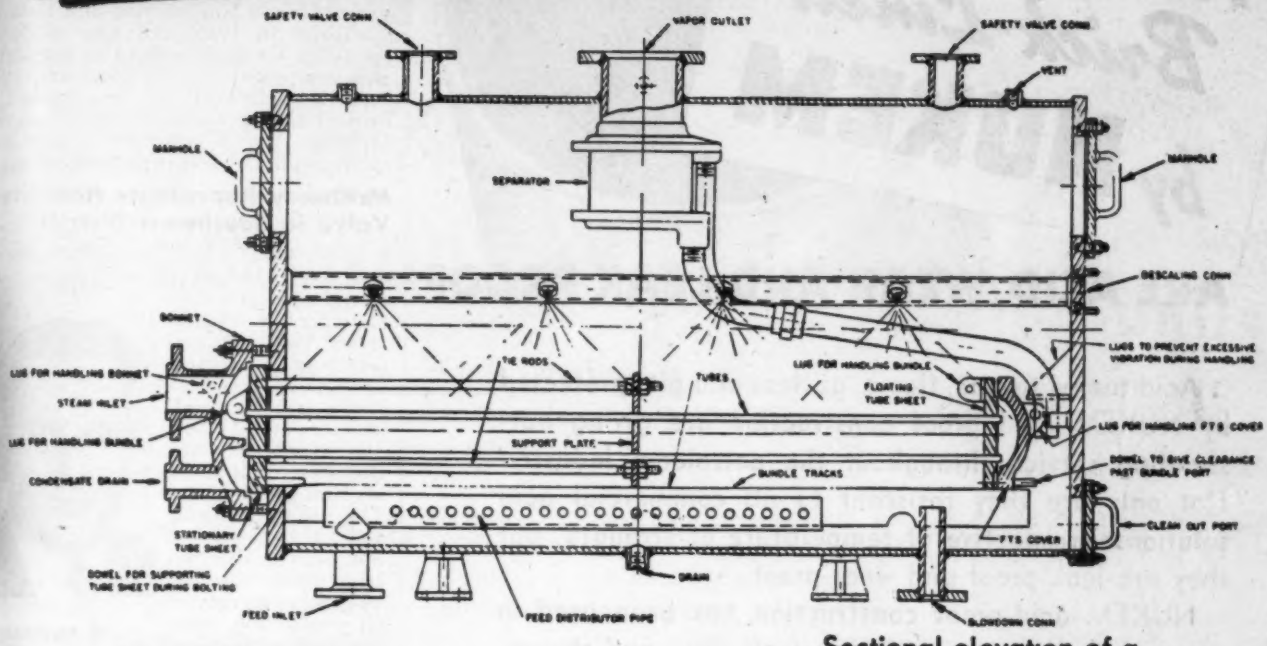
John L. Young Elected Vice President of National Tube

John L. Young has been elected to the newly created post of vice president in charge of engineering of National Tube Company. He has been vice president in charge of industrial research and development of United Engineering and Foundry Company, Pittsburgh.

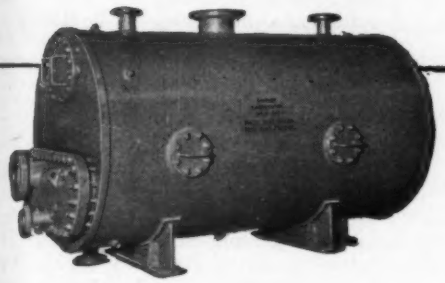
J. L. Young

A graduate of the University of Indiana, Young began his career with The Timken Roller Bearing Company at Canton, Ohio, where

ADEQUATELY DESIGNED for Operation and Maintenance



Sectional elevation of a
Lummus Power Plant Evaporator



PURE WATER FROM ANY RAW OR SALT WATER SUPPLY

Lummus experience . . . in designing and fabricating power plant evaporators to meet individual requirements . . . is your guarantee of a dependable supply of pure water from any raw or salt water source.

Full-efficiency operation is assured by a soundly based design that provides adequate vapor separators and liberal, properly balanced disengaging areas. Easy maintenance is assured by a practical understanding of field conditions. All connections are readily accessible and do not require disassembly within the unit to remove the tube bundle.

Lummus engineering service is always available for the study of specific heat exchanger problems and equipment design to meet individual power plant conditions. For further information write to: The Lummus Company, 420 Lexington Avenue, New York 17, N. Y.

LUMMUS EQUIPMENT

HEAT EXCHANGERS
•
PROCESS CONDENSERS
•
REBOILERS
•
STEAM GENERATORS
•
STEAM JET REFRIGERATION
•
STEAM SURFACE CONDENSERS
•
BAROMETRIC CONDENSERS
•
STEAM JET AIR EJECTORS
•
EVAPORATORS
•
BOILER BLOWDOWN HEAT EXCHANGERS
•
FUEL OIL HEATERS
•
LUBRICATING OIL COOLERS
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PIPE LINE COOLERS
•
FEED WATER HEATERS
•
JACKET WATER COOLERS

LUMMUS

HEAT EXCHANGERS

ACID TANKS *Brick-Lined* by NUKEM

ARE ACID, WEAR AND LEAK PROOF

Acid tanks, towers, floors, gutters and pits protected by NUKEM acid proof construction are giving outstanding service throughout the petroleum industry. Not only are they resistant to all commercial acid solutions irrespective of temperature or strength, but they are leak-proof and wear-proof.

NUKEM acid-proof construction has been used in processing and storage tanks of all sizes and shapes. NUKEM floors installed in 1930 are still in service with no time out for repairs. Wherever acid-proof construction is required, one of the various types of NUKEM acid-proof construction will give complete satisfaction.

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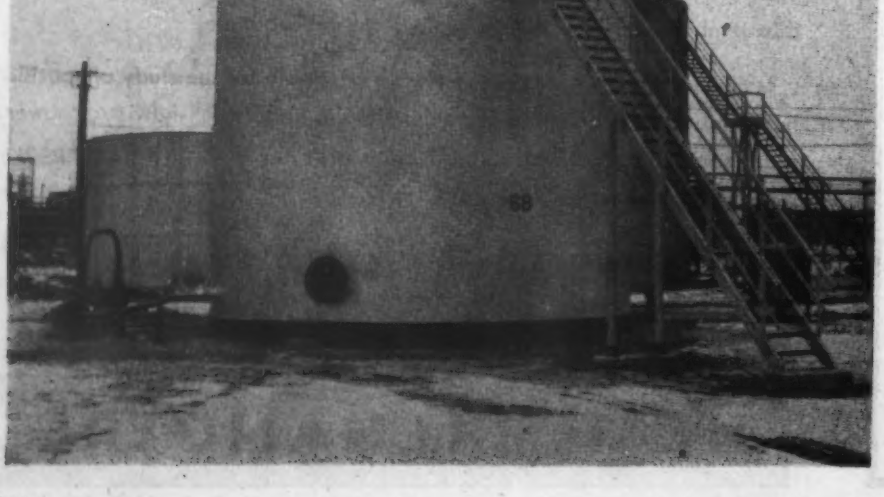
NUKEM PRODUCTS CORPORATION

115 COLGATE AVE. BUFFALO 20, N.Y.



he held various positions in the alloy tube and steel departments, later transferring to the metallurgical department working on operating problems from a metallurgical standpoint. In 1930 he went to Pittsburgh for the same company as a development engineer to study application of bearings in steel-mill machinery. Later he returned to Canton and became assistant general manager of the industrial division. He joined United Engineering and Foundry Company in 1936, and was made responsible for development of machinery and equipment for the steel and allied industries. In 1941 he was loaned as project manager to design and construct Defense Plant Corporation's aluminum rolling mills at Trentwood, Washington.

McKinney Represents Homestead Valve in Southwest District

I. W. (Dub) McKinney recently was appointed factory representative and Southwestern sales manager of Homestead Valve Manufacturing Company, Coraopolis, Pennsylvania, and has headquarters at 1711 Second National Bank Building, Houston. McKinney attended The Rice Institute and University of Southern California, after which he had 10 years service in oil production, pipeline construction, and refining, culminating with Humble Oil & Refining Company at Baytown where he was a member of the engineering inspection department.

I. W. McKinney

Safety Service Company Opens Houston Office

R. M. Hendrickson is branch manager of a recently opened office of United States Safety Service Company at 502 Caroline Street, Houston. Headquarters of the company are at Kansas City. Hendrickson has been associated with the company a year, and previously was a safety supervisor for Pratt & Whitney Aircraft Corporation for two years. Before that connection he was for 13 years with the industrial safety division of American Optical Company.

Foster Wheeler Corporation Has Two New Vice Presidents

John E. Kenney and E. R. Goodrich have been elected vice presidents of Foster Wheeler Corporation.

Kenney has been director of Western offices with headquarters at Chicago since 1940. A graduate of the University of Notre Dame, he joined Power Specialty Company, which is a part of Foster Wheeler Corporation, 23 years ago,

J. E. Kenney

E. R. Goodrich

Furfural

stages a treasure hunt

SEE HOW YOU CAN USE FURFURAL

The popularity of the Furans is growing and they are paying dividends to chemists who are alert to their possibilities.

Furfural in Oil Refining

Principal use for Furfural (Furfuraldehyde) is as a selective solvent. This special property is being widely exploited in the oil industry where more lubricating oil is now being refined by the Furfural process than by any other single solvent extraction process. Selective solvent action and other unique properties are being recognized in many additional fields.

Other Uses of Furfural

Production of butadiene is being facilitated by this versatile chemical in the role of a selective solvent. In various abrasive products, such as resinoid bonded wheels, coated goods and molded items, Furfural is extensively used as solvent, wetting agent and plasticizer. It is useful as a dispersant for cellulose derivatives, such as nitro cellulose and cellulose acetate and is one of the best solvents for reactive phenolic resins. In refining wood rosin, Furfural selectively extracts both latent and visible color bodies. A versatile chemical raw material, its almost unlimited reactivity is already figuring heavily in important current and postwar developments.

Furfural may have possibilities in connection with your products. Would you like more information and a research sample? We shall be glad to send both without cost when requested on your company letterhead.

Ample Supply Available

Furfural is so important to the war that it is still on allocation. However, it has been removed from Group 1 (critical materials) and we have been able to fill all normal requirements for civilian as well as military and lend lease uses since October. Ample supply for your regular needs is available at 9½ cents per pound in tank car quantities FOB Cedar Rapids, Iowa.

TYPICAL PROPERTIES—FURFURAL
(TECHNICAL)
(FURFURALDEHYDE, $C_4H_3O—CHO$)
Amber-colored liquid of high stability and unusual purity

Molecular Weight	96.08
Freezing Point, °C.	−37
Boiling Range (99%), °C.	157 to 167
Specific Gravity (20/20°C.)	1.161
Flash Point (Open Cup) °C.	56
Refractive Index (20/D)	1.5261
Surface Tension (dynes/cm)	49
Viscosity at 38°C. (Centipoises)	1.35

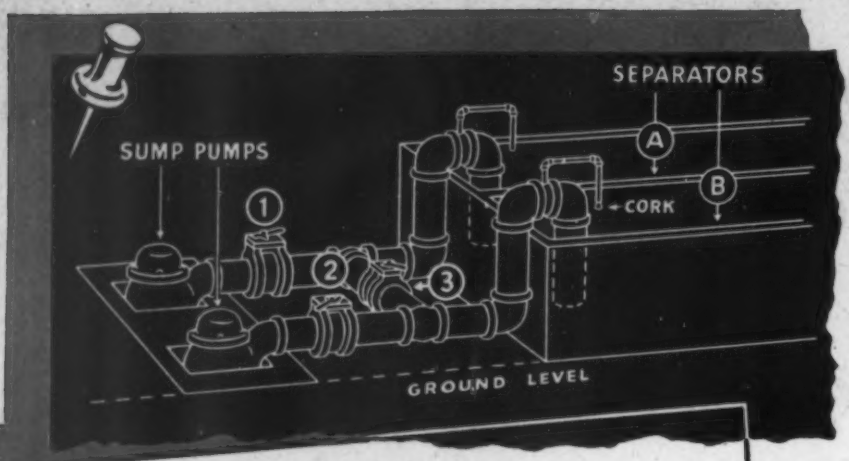
Solubility: Completely miscible with ethyl alcohol, ether, acetone, benzol, butyl acetate, China wood oil and most organic solvents except petroleum hydrocarbons and glycerol; 8.3% by wt. in water at 20°C.

The Quaker Oats Company

1830 BOARD OF TRADE BLDG.
141 W. JACKSON BOULEVARD . . . CHICAGO 4, ILLINOIS

CHEMICALS DEPT.

FURFURAL • FURFURYL ALCOHOL • HYDROFURAMIDE • TETRAHYDROFURFURYL ALCOHOL

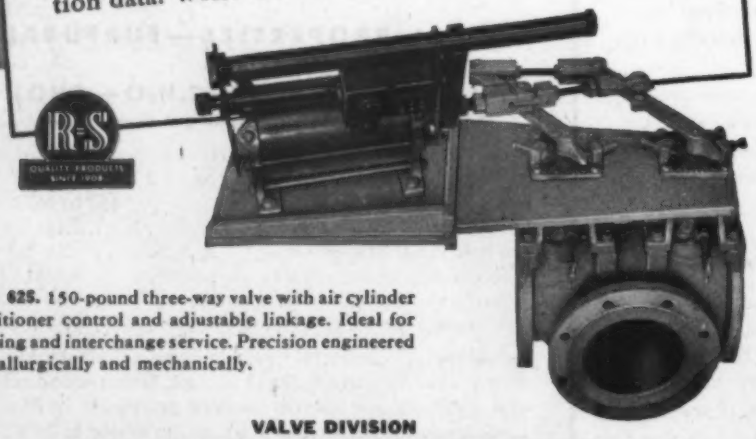


How to Control Sump Pump Discharge

The plant sewer lines drain into the sump where the waste is pumped into the concrete separators through R-S Valves Nos. 1 and 2. Valve 3 in the connecting line provides a means of cleaning either A or B separators, as the ¾-inch syphon breakers can be plugged with corks and the fluid syphoned from the separators to facilitate cleaning operations. The three 16-inch, 15-pound valves have 25-pound American Standard flanged drilling and are hand lever operated.

For fast, easy control and shut-off of volume and pressure, even under high pressure and temperature conditions, the R-S Butterfly Valve has no equal.

Prompt quotation furnished on receipt of installation data. Write for Catalog No. 14-B.



No. 625. 150-pound three-way valve with air cylinder positioner control and adjustable linkage. Ideal for mixing and interchange service. Precision engineered metallurgically and mechanically.

VALVE DIVISION

R-S PRODUCTS CORPORATION

120 Berkley Street • Philadelphia 44, Pa.

R-S Streamlined BUTTERFLY VALVES

and since has served in many important engineering and sales capacities.

Goodrich has been associated with Foster Wheeler Corporation since his graduation from the engineering school of Yale University in 1912, and has been in charge of the turbine division.

Heppenstall Vice President Of H. K. Porter Company

H. K. Porter Company has announced election of S. B. Heppenstall, Jr., as a vice president. He is to make his headquarters in the genereal offices of the company in Pittsburgh.

S. B. Heppenstall, Jr.

Heppenstall formerly was vice president in charge of sales for Heppenstall Company. He is a member of the Association of Iron and Steel Engineers and of the American Iron and Steel Institute.

Ohio Injector Company Names Greene General Sales Manager

The Ohio Injector Company, Wadsworth, Ohio, has announced appointment of Joe W. Greene as general sales manager. He has had many years of experience in the valve field, having made headquarters in the Southwest, Middle West and East for the past 20 years, handling the oil, power and construction industries.

J. W. Greene

The Ohio Injector Company a short time ago completed a new steel-valve plant which is one of the most modernly equipped in the country.

Kieley & Mueller Appoint New Pittsburgh Agent

Kieley & Mueller, Inc., North Bergen, New Jersey has appointed Jno. D. Hiles Company, Plaza Building, Pittsburgh, as agents in that area for level and pressure controls and steam specialties.

Burkhart Named Manager of Sales For Key Company

Key Company, East St. Louis, Illinois, has appointed M. E. Burkhart vice president in charge of sales, to replace B. J. Gross who has been transferred to the company's New York office, 420 Lexington Avenue.

Burkhart has been with the company

M. E. Burkhart

B. J. Gross

"A.W." SUPER-DIAMOND

PERMANENTLY SAFE UNDER ALL CONDITIONS

QUICK TO DRAIN

EASY TO CLEAN

READILY MATCHED

SEND FOR CATALOG

Other "A. W." products include:

Plates, Sheets, Billets, Blooms, Slabs — Carbon, Copper or Alloy analyses

SINCE 1826

ALAN WOOD STEEL COMPANY

CONSHOHOCKEN, PENNSYLVANIA :: District Offices and Representatives:

Philadelphia New York Boston Atlanta Buffalo Chicago Cincinnati Cleveland
Denver Detroit Houston St. Paul New Orleans Pittsburgh
Roanoke Sanford, N. C. St. Louis Los Angeles San Francisco Seattle Montreal

Like putting your plant
BESIDE A MOUNTAIN STREAM

Chlorination of process and cooling water is like having a mountain stream at your doorstep. No longer need raw water bacterial quality be a major factor in selecting a site for a new manufacturing plant . . . nor need a requirement for water of higher bacterial quality necessitate a change from your present location.

Wallace & Tiernan chlorination can eliminate the effect of pollution, making any raw water supply bacterially suitable for industrial cooling water or for process purposes, at a cost often less than the resulting yearly savings in fuel and manpower.

From their wide experience in solving water treatment problems in scores of different industries, Wallace & Tiernan Engineers will recommend the method best adapted to the individual needs of your plant.

CD-14

WALLACE & TIERNAN
PRODUCTS, INC.
Manufacturers of Chlorine and Ammonia Control Apparatus
Belleville 9, New Jersey — Represented in Principal Cities

18 years and has been chief engineer since 1939. Gross has been with the company 12 years and was manager of sales for the past 5 years. In New York he will be associated with G. C. Smith, who has been with the company more than 20 years.

Hejduk Meriam Instrument Company Vice President

Arthur A. Hejduk, a director, has been elected a vice president of The Meriam Instrument Company, Cleveland. He has been connected with the company 11 years, for the past several years as manager of sales and engineering.

Westinghouse Shortens Name, Splits Corporate Shares

Westinghouse Electric and Manufacturing Company has shortened its name to Westinghouse Electric Corporation, and increased the number of its shares from 4,000,000 of $50 par to 16,000,000 of $12.50 par. Reclassification of the stock will not in any way change the preference of relative rights of the stockholders, it was explained, and there will be no change in the terms of either the preferred or the common. There are now about 48,000 stockholders, none owning more than 1.5 percent of the stock.

Eagle-Picher Drops Lead From Corporate Name

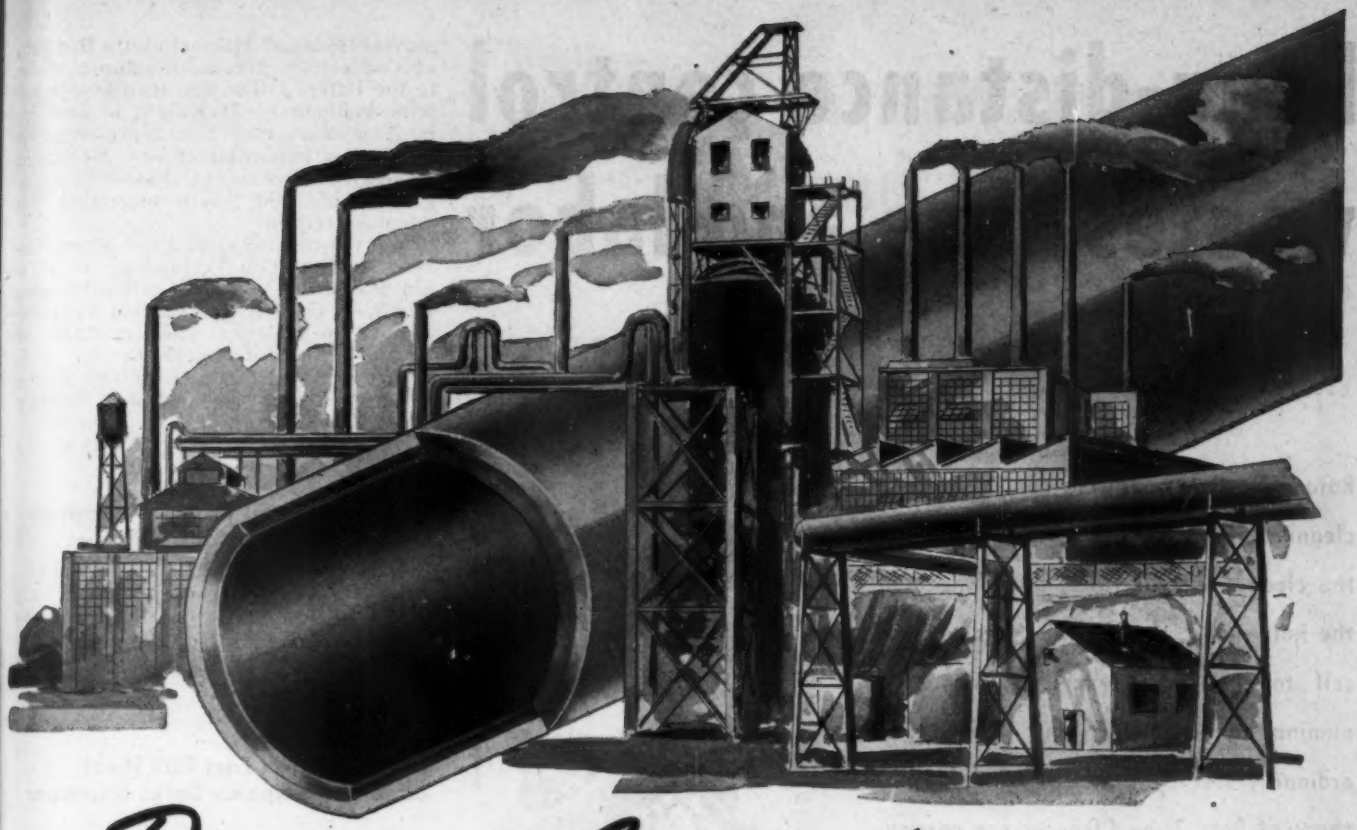
The Eagle-Picher Lead Company now is The Eagle-Picher Company, following action by stockholders at a recent meeting in Cincinnati, dropping the word "lead" from the name because the management felt that it restricted the public concept of the scope of the company's activities. The company long has been a major factor in mining and smelting of zinc and an important producer of slab zinc and zinc oxides. It also is one of the largest fabricators of mineral wool insulation. No changes of personnel are involved, and no change in the corporate setup of two wholly-owned subsidiaries, The Eagle-Picher Mining & Smelting Company, and The Eagle-Picher Sales Company.

Foster Wheeler Makes Three Staff Members Directors

Foster Wheeler Corporation has announced election of William L. Martwick, Lee A. Swem and Charles E. McCulloch as directors of the corporation.

Martwick, after spending several years in the work of fuel preparation, furnace design and combustion, became president of Aero Pulverizer Company which was absorbed by Power Specialty Company in 1926. The latter then organized a pulverizer and furnace division with Martwick as manager, an arrangement which was continued after Power Specialty Company was succeeded the following year by Foster Wheeler Corporation. In 1932 Martwick went to Chicago as director for Foster Wheeler Corporation's western offices, and five years later was appointed general sales manager with headquarters in New York. He has been a vice president since 1940.

Swem has been the corporation's patent counsel since 1936, and before that while in private practice devoted considerable time to its patent problems. He graduated from Georgetown University Law School in 1926, after having studied mechanical engineering in that



Divide and Conquer!

YOUR CORROSION PROBLEMS WITH BRIDGEPORT DUPLEX TUBING

"Divide and Conquer" can be mighty effective strategy when dealing with a severe corrosion problem. In chemical plants and refineries, serious and costly interruptions in the operation of major equipment are often caused merely by the corrosion of tubing or piping used in the system. Because of the nature of the corrosion which exists on both sides of the tubing it is difficult to find material which will stand up satisfactorily from double attack.

Such difficulties can often be solved by approaching the problem on the principle of divide and conquer. Two tubes, each one of a different metal or alloy, are combined to make Bridgeport Duplex Tube with inner and outer walls capable of withstanding the two different types of corrosion involved, thereby solving corrosive conditions which defeat a single metal or alloy.

Bridgeport's Duplex Tubing is available in almost any combination of ferrous and non-ferrous materials.

For ammonia refrigeration systems, for example, steel has been specified for the ammonia side and copper for the water side. Chemical plants have been supplied with Duplex Tubes composed of Admiralty outside for brackish water and aluminum or other metals inside. Other applications have called for Bridgeport's Cuzinal, Red Brass, Admiralty, Copper, Duronze IV and Cupro Nickel in combination with aluminum, steel, or monel metal.

Let our nearest Bridgeport office show you how Duplex Tubing can divide and conquer your double corrosion problems. For preliminary information write for Bridgeport's technical bulletin describing applications and practical installation methods.

•

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Condenser and Heat Exchanger Tubing

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Long-distance control wastes time and labor in tube cleaning

Roto offers you operating control of tube cleaners where you need it most, right at the cleaner. An air valve, directly behind the Roto motor, permits the operator himself to turn air on and off instantly, eliminating the helper and saving time ordinarily lost by signalling. The advantages of Roto Tube Cleaners are particularly noticeable where a number of them are in simultaneous operation. Why not enjoy the time- and labor-saving features of Roto Tube Cleaners now, when you need them most?

ROTO
TUBE CLEANERS

ROTO Division of Elliott Company
145 Sussex Ave., Newark 1, N. J.

university and at Massachusetts Institute of Technology. He became an examiner in the Patent Office and then associated with William G. McKnight in practice in New York, the firm representing a number of important clients. McKnight was patent attorney for Foster Wheeler Corporation and Swem succeeded him when he retired.

McCulloch graduated from Massachusetts Institute of Technology in 1926, and joined the National Carbon Division of Union Carbide and Carbon Corporation as an analytical chemist. Later he became chemical engineer for Tide Water Oil Company. He joined Foster Wheeler Corporation's refinery division in 1927, and ten years later was appointed manager of the division, the position he now holds.

National Airoil Burner Company Opens Houston Sales Office

National Airoil Burner Company, Philadelphia, has opened a temporary office at 2015 Second National Bank Building, Houston, preparatory to making arrangements for more extensive operation in that territory. Initially the office is in charge of Edward P. Bailey, president of the company.

Daerr Named Fort Pitt Steel Casting Company Sales Manager

N. K. Daerr has been appointed sales manager for Fort Pitt Steel Casting Company. He has been associated with the organization since 1923, and since 1940 has been sales engineer in the Eastern territory. He has served as chairman of the technical group of the Steel Founders' Society of America, Pittsburgh district, and has been active in promoting many steel casting developments.

Other sales department appointments announced by the company include S. B. Nicholson, associate sales manager, and Harry J. Hatt, H. Ellwood Rankin and M. L. Murray, sales engineers.

Baton Rouge Plant to Make Ethyl Chloride by New Process

A new process for making ethyl chloride is announced by Ethyl Corporation. A $750,000.00 unit employing this process is under construction at the company's Baton Rouge plant.

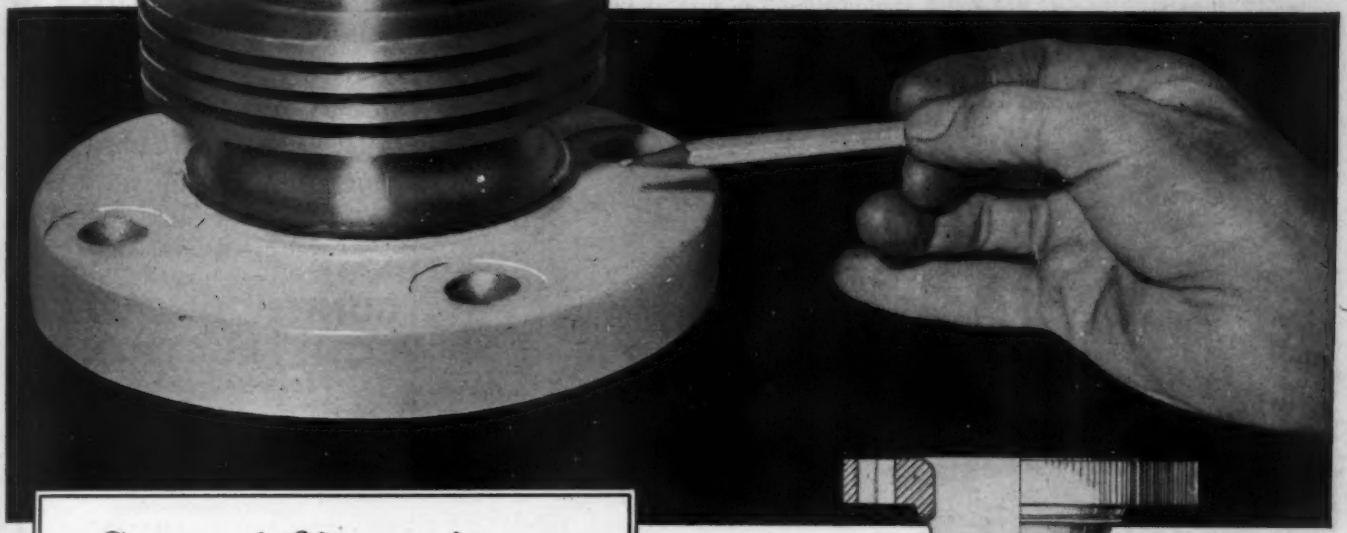
The process yields ethyl chloride by reacting chlorine with waste products from one of the present ethyl chloride units. It was developed in view of the "tight" supplies of both alcohol and ethylene, compounds used in producing ethyl chloride, through two present processes.

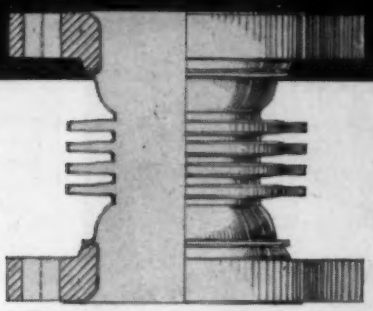
The principal use of ethyl chloride is in making tetraethyl lead by combining it with an alloy of lead and sodium. It is used in dentistry as an anesthetic on abscessed gums, as a general anesthesia in short operations, in producing ethyl cellulose which is the basis for certain plastics, as a catalyst in synthetic rubber manufacture, as a constituent of cognac essence, and sometimes as a refrigerant.

Chlorine for the new process is produced by breaking salt electrically into chlorine and sodium. The sodium from this electrolysis is combined with metallic lead to form a lead-sodium alloy used in making tetraethyl lead.

The two methods already in operation for making ethyl chloride are based (1) on the hydrochlorination of alcohol, and

A NEW Expansion and Pressure Member...





Specifications

1. End flanges 150 lbs. standard forged steel ASA requirements. ASTM and ASME specifications.
2. Van Stone lap, slip style, for self alignment of end flange bolt holes.
3. Face to face dimensions 6" O.A. free length.
4. For vacuum service. Micron tight.
5. For pressures ranging from 0 to 55 lbs. p.s.i.
6. Total travel of bellows illustrated ½", can be used on compression or expansion.
7. Spring rated bellows provide uniform travel.
8. Long life. Cycleage in average use upwards of 10^6.
9. Temperature range—300°F. to 900°F.
10. For corrosive gases or liquids.

Available in standard pipe sizes from 2" to 6" inclusive, they can be supplied with additional bellows flanges for greater travel ranges. Face to face dimensions increase accordingly. When ordering specify type of service and whether used for vacuum or pressure applications. These bellows are designed for specific services and applications. All prices quoted on request.

MAGNI LASTIC

EXPANSION JOINTS

Here is a new, vacuum and medium pressure, expansion joint recently developed by Cook Electric Company, made of Monel metal. It responds to hand pressure flexing, yet is capable of meeting all of the requirements as listed in the specifications at the left. It is used for chemical, diesel, oil, special process and steam line applications.

MagniLastic bellows, through their use of all metals and modern metal joining techniques, can be incorporated into many advanced industrial units. Let MagniLastic solve your unusual bellows problems.

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(2) on the hydrochlorination of ethylene. In the alcohol process, ethyl alcohol vapor and hydrochloric acid combine in the presence of a catalyst to form ethyl chloride and water. In the ethylene process, ethylene gas is mixed with hydrogen chloride gas in the presence of a catalyst. The two gases first are passed through a reactor where hydrochlorination occurs, and later through a flash drum which distills off the lighter ethyl chloride fractions, leaving the heavier polymer fractions. The ethyl chloride then is purified by fractionation. The first of two plants using the ethylene process was built in 1939.

Before the war, Ethyl Corporation converted all the chlorine from electrolysis of salt to hydrogen chloride to make ethyl chloride, and bought additional amounts of chlorine elsewhere. Due to rising demands for chlorine, the company overproduced sodium in 1941 to obtain more chlorine, discontinuing open market purchases of chlorine, and storing the surplus sodium.

When chlorine supplies became critically short, Ethyl Corporation expanded its plant facilities to substitute hydrochloric acid for chlorine, producing the hydrochloric acid from sulphuric acid and common salt.

Then ethyl alcohol came increasingly into demand. Construction of a second ethylene plant at Baton Rouge for the production of ethyl chloride helped to relieve the supply situation in ethyl alcohol.

As the war progressed, supplies of ethylene in the Baton Rouge area became inadequate in meeting demands for ethyl chloride needed to manufacture Ethyl fluid. When the new plant is in production, Ethyl Corporation expects to meet all increased requirements for ethyl chloride for tetraethyl lead without additional drain upon available supplies of alcohol or ethylene.

Tubular Exchanger Manufacturers Elect George A. Worn President

George A. Worn, The Lummus Company, New York, was elected president of the Tubular Exchanger Manufacturers Association at its recent annual meeting. William Bisch, The Griscom-Russell Company, New York, was named vice president, and W. J. Parker, secretary-treasurer. H. W. Conarro, Struthers-Wells Corporation, Warren, Pennsylvania, was elected a member of the executive committee, and W. C. Beekley, The Whitlock Manufacturing Company, Hartford, Connecticut, ex-officio member of the executive committee.

The meeting was held at headquarters of the association, 366 Madison Avenue, New York 17.

General American Advances Lissauer to Vice President

Arthur W. Lissauer, general manager of General American Transportation Corporation's Process Equipment Division, has been elected a vice president of the corporation. Lissauer, a chemical engineer, has been active in various engineering and chemical enterprises since his graduation from Columbia University in 1909. He is president of Louisville Drying Machinery Company, acquired by General American in 1943.

Other changes in the corporation's corporate set-up include advancing Lester N. Selig, president, to vice chairman,

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NATIONAL FOAM

Blankets and Effectively Extinguishes

Oil, Tar, Gasoline and most Chemical Fires

These tar and chemical plant buildings were dependent on water for fire protection.

A gastight foam blanket is the surest and quickest way to deprive a fire of oxygen without which it cannot persist.

All foams are not equally effective fire extinguishers. The basic material that makes National Foam more effective is derived from Soy beans —that's why the Navy call it "Bean Soup." National Foam bubbles are tough, cohesive and adhesive. National Foam quickly produces a thick gastight blanket which smothers the fire, cools the surface and prevents flashbacks.

National Foam proved its efficiency the hard way, conquering first the toughest and most hazardous field — oil and gasoline fires. The success of Foam in this field was so outstanding and efficient that until recently almost the entire output and attention of the National Foam System was devoted to this phase of fire extinguishing.

The U. S. Navy have installed foam fire fighting equipment on all their ships, for protection against oil, gasoline and other hard-to-control fires. Until recently, the Navy have required the entire output of Aer-O-Foam. A limited amount can now be offered for civilian use.

National Foam System provides both portable and stationary units. No extensive or complicated installations are required to produce National Foam *in volume.*

Our engineers will gladly consult with you and recommend the Foam and Equipment best suited to your needs.

BACK THE ATTACK—BUY WAR BONDS

NATIONAL FOAM SYSTEM, INC.

Specializing in Foam Fire Protection

Packard Building, Philadelphia 2, Pa.

For the Safety of SHIPS . . .

America needed ships . . . 50,000,000 tons of cargo, tanker and transport ships, in addition to a vast fleet of Naval vessels—*and all of these ships needed safety valves, relief valves, and pressure gauges!*

Where did all these valves and gauges come from? Lonergan produced a lot of them . . . thousands of tons of them . . . and did so in addition to serving many of America's other vital war industries.

The facilities and 73 years of "know-how" that made possible this production achievement are at your service whenever you need *Safety Valves, Relief Valves,* or *Pressure Gauges.* Get Lonergan recommendations on your next inquiry.

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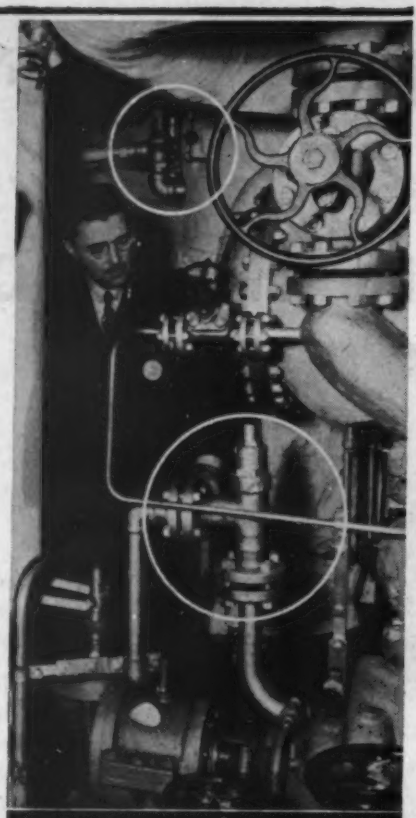
Safety Valves • Relief Valves • Pressure Gauges
SINCE 1872—Makers of Pressure-Safety Appliances for the Power, Mechanical, and Process Industries



TWO OF MANY TYPES OF LONERGAN RELIEF VALVES USED ON SHIPS

OFFICIAL U. S. NAVY PHOTO

Bulletin 22-23-B-11 gives detailed information on the Rotary Positive Displacement principle and its advantages. Characteristic curves are shown for different drives, together with sizes, dimensions, and complete specifications. Numerous installation photos show various applications for Rotary Positive Blowers. Write for your copy of Bulletin 22-23-B-11. Also ask for Bulletin 21-B-35 covering smaller sizes.

ROOTS-CONNERSVILLE BLOWER CORP.
One of the Dresser Industries
505 Crescent Avenue Connersville, Indiana

Roots CONNERSVILLE SINCE 1854 Rotary Positive BLOWERS

election of Sam Laud as president, W. S. Hefferman, Jr., formerly secretary, as vice president, and appointment of Frank E. Selz as assistant to the president. Max Epstein remains chairman of the board.

Wescott and Greis Moves Val Link to Dallas Office

After eight years as sales engineer at the Shreveport office of Westcott and Greis, division of American Meter Company, Val Link is now serving in the same capacity at that company's Dallas branch.

Val Link

A graduate of St. Mary's College, San Antonio, Link began his career with United Gas System. When he left that organization in 1937 he was in charge of the measurement department of the Laredo-Bruni District.

In addition to his engineering background and experience, knowledge of Spanish has enabled him to be of special service to companies operating in Mexico.

Elliott Company Executives Given Broader Responsibilities

W. A. Elliott, vice president in charge of sales for Elliott Company, Jeannette, Pennsylvania, has been named executive vice president, and Ronald B. Smith, manager of engineering research and development, was elected vice president in charge of engineering. F. W. Dohring, general sales manager, was given added responsibilities as assistant to the executive vice president.

Dorr Company Assigns Camp to Foreign Sales

A. D. Camp has been assigned by The Dorr Company to its foreign sales division. He previously has served the company as manager of the technical data divison, and as advertising manager.

Baker Product Engineer For Elliott Lagonda Unit

V. H. Baker has been appointed plant manager and product engineer for Lagonda Division of Elliott Company, Springfield, Ohio. Baker has been associated with Elliott Company for 35 years.

Maxim Silencer Company Gets Fourth E Award

Maxim Silencer Company, Hartford, Connecticut, recently was awarded a third star for its Army-Navy E production award burgee. The company's product is widely used on ships as well as on industrial diesel engines.

Edward Valve Gets Another Maritime Commission Award

The Edward Valve & Manufacturing Company, East Chicago, Indiana, has been awarded the fifth gold star for its Maritime Commission M pennant.

NEW EQUIPMENT

...MANUFACTURERS' · LITERATURE...

FOR FREE COPIES OF MANUFACTURERS' LITERATURE OR MORE INFORMATION ON PRODUCTS DESCRIBED ON THESE PAGES, USE THE MAILING CARD INSERTED IN THIS ISSUE

1—Expansion and Pressure Member

Cook Electric Company, 2700 Southport Avenue, Chicago 14, announces a new vacuum and medium pressure expansion joint made of Monel metal. It responds to hand pressure flexing, yet is capable of meeting these specifications: for vacuum service, micron tight; pressures ranging from 0 to 55 pounds per square inch; total travel of bellows illustrated ½ inch, can be used on compression or expansion; temperature range 300 to 900° F. It is used for chemical, diesel, oil, special process and steam-line applications.

The member is available in pipe sizes from 2 to 6 inches, and can be supplied with additional bellows flanges for greater travel ranges.

Cook Electric Company's new expansion and pressure member.

2—Remote Mechanical Control

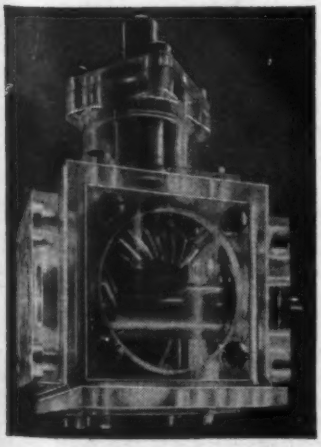
M. L. Bayard and Company, 1902 Indiana Avenue, Philadelphia 32, has announced a standardized system of remotely operated mechanical controls for use on such equipment as cranes, winches, windlasses and stearing gears, and for operating large valves with motors, ventilators, furnace doors, factory windows, etc.

The related units are suitable for power operation under speeds not exceeding 1800 rpm. Terminal connections are consructed so that rearrangement of the same units can be made without disturbing the assemblies or affecting their internal adjustment.

The steady shaft assembly is engineered in two standard types. One is for attachment to surface which is square to the shaft. The other is for attachment to surface which is parallel to the shaft.

Full freedom is possible with the Spiral bevel gear assemblies because all shaft ends are interchangeable. Either two shaft ends or three shaft ends, depending upon the type desired, are connected to other control units.

The universal shaft assembly is made in lengths ready to be installed, or with one end yoke to be field welded after the tube is cut to suitable length. Telescoping splined portion between the end yokes permits ready installation and removal without disturbing the other control units.



Bayard spiral bevel gear assembly.

3—Supercharging of Gas Engine

The Cooper-Bessemer Corporation, Mount Vernon, Ohio, has announced a development which makes possible supercharging a gas engine, and permits instantaneous conversion from use of either oil or gas fuel.

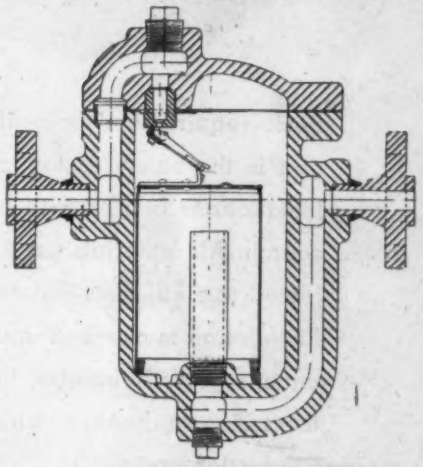
In tests conducted by company engineers on its LS 8-cylinder gas-diesel engine, which had an ordinary rating of 1100 horsepower, the engine was supercharged up to a rating of 1600 horsepower at 327 revolutions per minute. When the engine was changed over to gas the engine exhaust temperatures were decreased and the turbo-charger speed was lowered. The reason assigned for the lower exhaust temperature was better combustion on gas than oil. The lower turbine speed is the result of better combustion, but proves scavenging was with pure air and not with gas, since if any gas was blown through it would burn in the exhaust manifold. The engine readily carried a 10-percent overload on gas.

On the supercharged engine, since it has a positive pressure on the air supply, the inlet and exhaust valves are timed so there is a period they are open together. A quantity of air is blown through the cylinder, expelling the burned gases. The exhaust valve then closes, permitting a charge of pure air in the cylinder.

4—Steam Trap

Armstrong Machine Works, 852 Maple Street, Three Rivers, Michigan, has announced a new cast-steel inverted-bucket steam trap with side inlet, side outlet connections, designed for pressures up to 600 pounds, or where all-steel fittings are desired. It is available with ½-, ¾- or 1-inch screwed or flanged connections. Flanges are welded into the trap body. Height is 11¼ inches; dimensions between flanges range from 11⅜ to 12⅛ inches, depending upon pipe sizes.

The inverted bucket and valve lever are made of 18-8 stainless steel; the valve and seat are chrome steel, hardened, ground and lapped. One of the features of the trap is that the cap and interior mechanism can be removed for inspection or repair without breaking either the outlet or inlet connections. The cap and working parts are removed as a unit by unbolting the cap, leaving the body intact on the line.



Armstrong Steam Trap

5—Explosion-Proof Motor

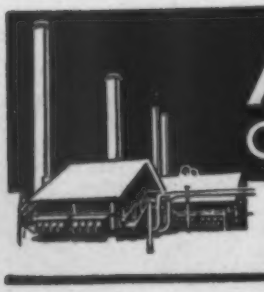
General Electric Company, Schenctady 5, New York, announces a new Class I, Group C, explosion-proof motor for atmospheres containing ethyl-ether and similar vapors. Recommended for use in chemical plants, hospitals and research laboratories, the new motor was tested and listed by the Underwriters' Laboratories in July, 1944.

Available in frame sizes 204-326, and in Types K (normal torque) and KG (high-starting-torque), the new motor is rated ¼ horsepower at 600 rpm to 20 horsepower at 3600 rpm, 110, 208, 220/440, 550 volts, 60, 50, 25 cycles. The construction is essentially the same as the Class I, Group D motors, but a special flamepath is used at the shaft openings to cool the flame of internal explosions. Thermostats operate in conjunction with a magnetic controller to

Basic requirement for achieving top refining production is the safety factor in heaters. Safety in Alcorn installations begins with careful engineering and research. All materials used in Alcorn heaters are subjected to rigid tests before assembly. Every detail of installation is checked and rechecked to insure maximum safety. Refineries throughout the world have used Alcorn heaters with confidence and lowered production costs.

Where new installations are not feasible under today's restrictions, production may be increased by modernization of existing heaters. Alcorn, by reallocating heating surface and adding floor tubes, can give heaters 15% to 50% increased capacity with improved operations and more uniform heat.

Secure Alcorn's advice for new installations or replacements. Write today.



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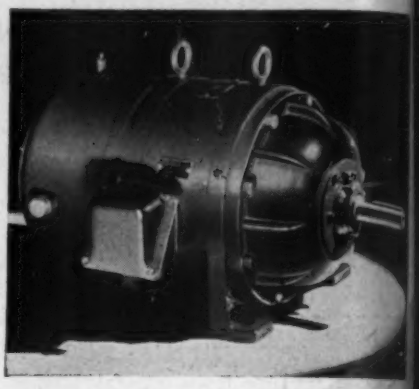
For copies of manufacturer's literature or additional information on products described, use the mailing card inserted at page 257. Numbers on card correspond to descriptive paragraphs.



General Electric Company's new explosion-proof motor for atmospheres containing ethyl-ether and similar vapors.

disconnect the motor at a predetermined temperature, but do not supplant regular overload relays.

Other features of this motor include a cast-iron stator, a four-position cast-iron conduit box, and strong end shields of high-grade, corrosion-resistant cast iron with reinforcing cooling ribs. Effective cooling is provided by a non-sparking fan, and a convenient pressure-relief system provides for ease of lubrication without disassembly of the motor.

Additional information is contained in bulletin GEA-4417.

6—Plastic Coatings

Oil Trading Company, 30 Rockefeller Plaza, New York 20, announces development of plastic exterior coating films which it claims are unaffected by exposure to petroleum products or vapors, dilute mineral acids of alkalis, such as hydrogen sulphide, sea water, salt in air or solution, oxidizing agents as nitric or chromic acids; are non-conductors and, therefore, prevent electrolytic corrosion; have high degree of ductility, excellent abrasion resistance; being fireproof, they will not support combustion; effectively prevent corrosion for long periods; are applied in same manner as paints and fall in the same price range. Interior coatings have the same characteristics and remain unaffected by crude oils, gasoline, distillates and other fractions of lower than 30 percent aromatic content. Different coatings are specifically recommended for various corrosion problems. Suggested applications are: barge, storage, tank, pipe lines and equipment exteriors; storage tank, tank car and drum linings.

7—Rotameter Tube

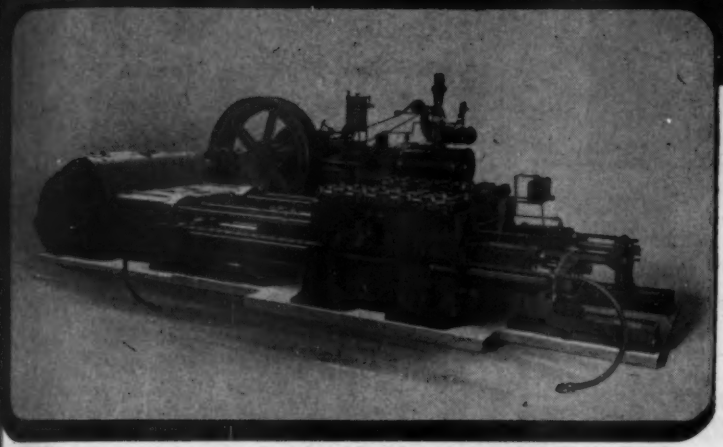
Fischer & Porter Company, 919 County Line Road, Hatboro, Pennsylvania, has announced a new rotameter tube made of boro-silicate glass, called the "bead-guide tube," which it claims greatly simplifies rotameter construction. Three straight glass ribs running up the inside of the tube guide the float throughout its travel, with only hair-line contact between the float and each raised rib.

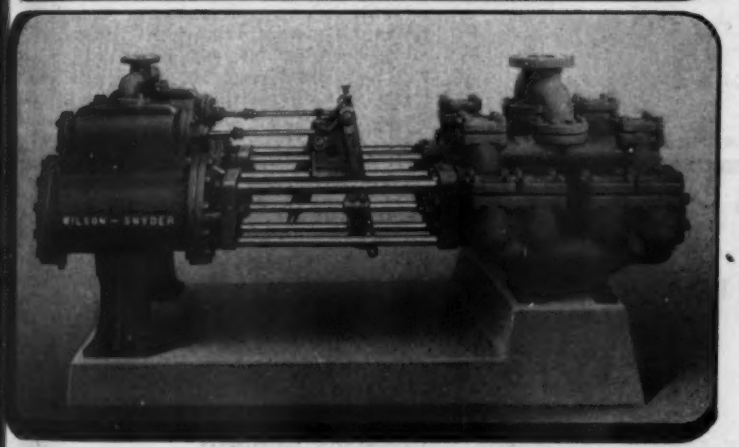
A guided float, the manufacturer ex-

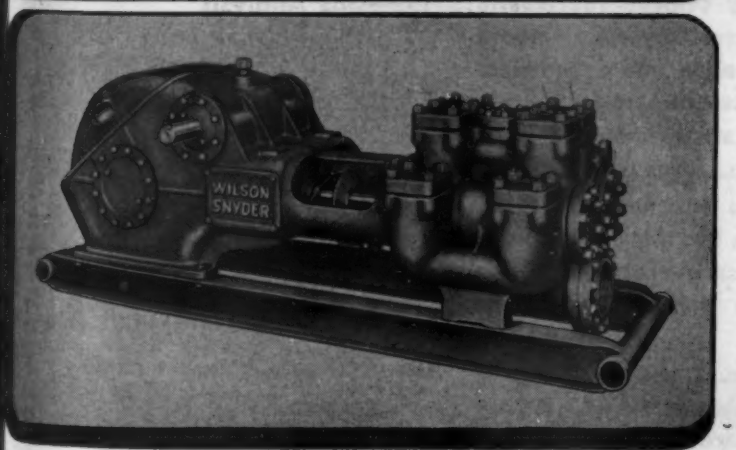
WILSON-SNYDER

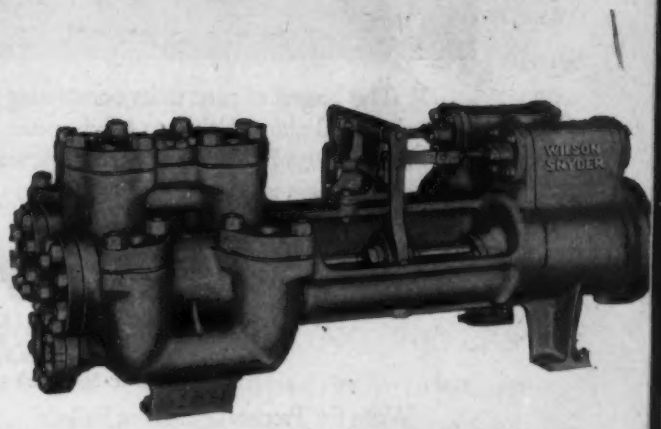
Quality Pumps

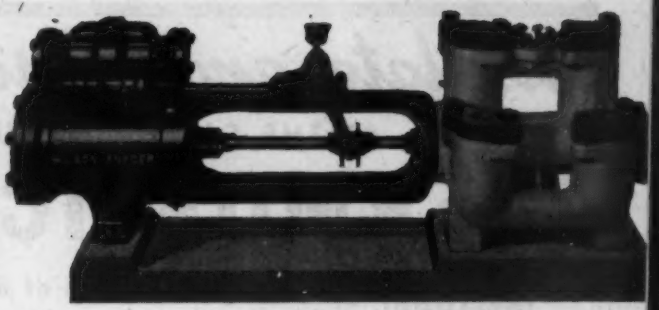
AN ECONOMICAL TYPE FOR EVERY REFINERY PROCESS











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The largest of nine units comprising an entire chemical plant. Column; 8ft diameter, 50ft long, 18 decks, 136 bubble caps each deck, welded steel shell. Engineered and fabricated by

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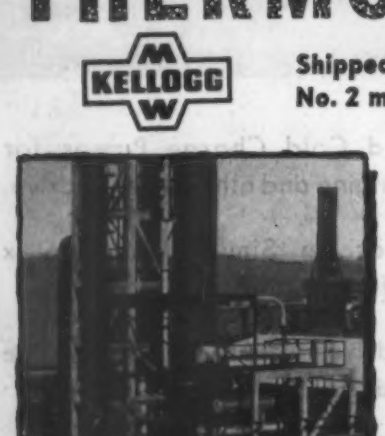
KELLOGG

Shipped in the form of dry cement Thermostic No. 2 mixes readily with water to form a smooth working; light weight and economical rust inhibited insulation for monolithic construction on stills, tanks, heat exchangers, towers, furnace walls, etc.



Users find this rust inhibited light weight insulation has a greater coverage capacity than average insulation and is unusually adhesive to hot or cold surfaces.

Thermostic No. 2 will not deteriorate and can be reclaimed for use again if temperatures have been maintained below 1200°F.

A test will prove its money-saving value to you.

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Sales Office: 225 Broadway, New York 7, N. Y. *Plant: Jersey City, N. J.*

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plains, improves accuracy of the rotameter by centering the float, and it also prevents tube breakage. Construction is simplified by elimination of a guide wire for stabilization of the float. It also solves the problem of how to guide the float when corrosive chemicals are being measured.

The new tube is readily adapted to existing rotameters.

8—Fire-Fighting Nozzle

Dugas Division of Ansul Chemical Company, Marinette, Wisconsin, has announced development of a new dual-stream nozzle which increases the fire-fighting effectiveness of its wheeled models. The new nozzle permits application of dry chemical on a fire either as a long-range straight stream or as a short-range fan stream. With the new nozzle, it was said, overhead fires can be extinguished successfully.

9—X-Ray Diffraction

North American Philips Company, 100 East 42nd Street, New York 17, is distributing a new 12-page booklet that describes X-ray diffraction techniques and applications. Diagrams, typical diffraction films, and several tabulations are given in order to show how this company's equipment is used for identification, research and production.

10—Automatic Metering System

Hetherington & Berner, Inc., Indianapolis, Indiana, has issued Bulletin F-44 on the Fulidometer automatic system for metering either light or heavy liquids. The bulletin shows installation illustrations and diagrams on the system for automatically measuring, either in pounds, gallons, barrel or tank-car lots any liquid of either high or low viscosity and not containing abrasive solids, that can be handled through a pipe.

11—Gas Analysis

Burrell Technical Supply Company, 1940 Fifth Avenue, Pittsburgh 19, is distributing its Catalog 80, which in addition to illustrated descriptions of its gas-analysis apparatus includes the "Burrell Manual for Gas Analysts." The whole is presented in a handsomely printed 96-page book.

12—Tube Cleaner

Elliott Company, Lagonda Division, Springfield, Ohio, is distributing a new four-page folder, Bulletin Y-19, on the Lagonda Type 1300 series tube cleaner, emphasizing an improved lubrication system for these machines. A cutaway view of the motor and its operation in curved tubes are shown.

13—High-Temperature Properties of Steels

The Timken Roller Bearing Company, Canton 6, Ohio, has issued a 50-page book based on a series of lectures presented before the 1945 Spring lecture course of the ASM Golden Gate Chapter, San Francisco, by Dr. C. L. Clark, the company's metallurgical engineer. The booklet contains over 100 illustra-

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. . . there is no substitute!

30 YEARS TO DATE

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New-comers in the Filter manufacturing field have admittedly selected G-B FILTERS as their model for imitation. Investigation and study are the only means of determining the marked superiority of GOSLIN-BIRMINGHAM FILTERS over the products of embryo enterprise.

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For strength and simplicity, only two parts are used — bearing bars which carry the load and have curved slots punched ABOVE THE NEUTRAL AXIS, and cross bars, of the same cross sectional area as the slot itself, pressed into these slots to distribute the load. No rivets, bolts or welds are required, thus eliminating the possibility of loose joints. Tri-Lok flooring comes in rectangular, diagonal and U shapes with Safety Steps — ask for Bulletin 1140 — DRAVO CORPORATION, NATIONAL DEPARTMENT, 300 Penn Avenue, Pittsburgh (22), Pa. (Distributor for THE TRI-LOK COMPANY)

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tions and is a basic treatment of the factors involved in the selection and performance of steels at high temperatures, together with a historical development of steels now used for this type of service. Data presented is based on the high-temperature research program conducted by The Timken Roller Bearing Company during the past 17 years.

14—Valve Maintenance

Merco Nordstrom Valve Company, 400 N. Lexington Avenue, Pittsburgh 8, is distributing Bulletin V-126, a manual to guide users of Nordstrom valves in the proper methods and routine of lubricating plug valves. It illustrates each type of valve, revealing the operation, and gives specific directions how to lubricate, when, and the type of lubricant best suited for specific services. This bulletin will serve as a convenient reference for service men, plant operators and others responsible for efficient valve operation.

15—Detergents

Optimus Detergents Company, Matawan, New Jersey, has issued Bulletin 4 D 1, which announces its line of industrial metal-cleaning materials, designed to cover a wide range of specific applications.

16—Protective Coatings

Reilly Tar & Chemical Corporation, Merchants Bank Building, Indianapolis 4, Indiana, has issued Bulletin 2-PC-45, which describes, showing typical applications, the company's protective coatings for metal, brick, cement and wood surfaces.

17—Mercurial Laboratory Instruments

Precision Instrument & Thermometer Company, 1934 Brandywine Street, Philadelphia 30, has available a 64-page manual which includes instruments specifically designed for process control and testing. Also included are data on application and installation of a complete line of laboratory instruments.

18—Centrifugal Pump

Allis-Chalmers Manufacturing Company, Milwaukee 1, Wisconsin, has issued a new bulletin on single-suction pedestal type centrifugal pumps which it has developed for use where close-coupled motors are not practical. The pumps are direct connected or belt driven by motors or engines. Included are cross-section drawings and standard specifications.

19—Valves

Merco Nordstrom Valve Company, 400 N. Lexington Avenue, Pittsburgh 8, has issued a complete new revised catalog, No. 9, 134 pages of valve listings and specifications, engineering tables, lubricant data, etc. Numerous revisions have been made in the specification tables, and many new and useful engineering tables have been added. Parts

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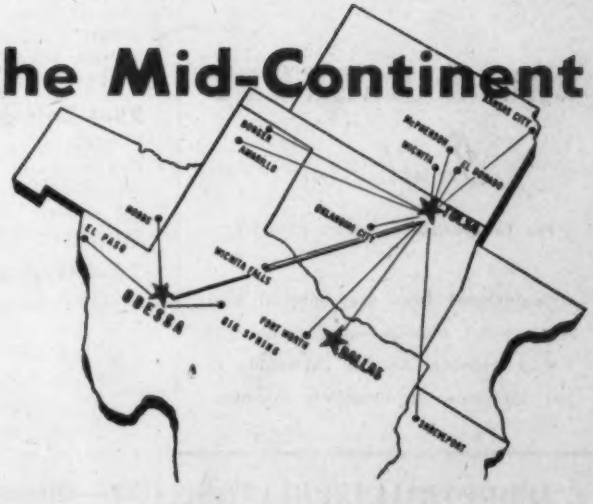

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HOUSTON, TEXAS ★ SHREVEPORT, LA.

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for the various types of valves are illustrated, and detailed drawings show features of construction.

20—Heat Transfer Equipment

The Whitlock Manufacturing Company, 48 South Street, Elmwood, Hartford 1, Connecticut, is distributing its Bulletin No. 645, which describes and illustrates Whitlock heat-transfer equipment, including shell and tube and tube-and-coil types. The bulletin illustrates design considerations pertinent to the chemical processing field, such as tube bundle and closure construction. Engineering data includes tabulations of capacities and dimensions of heaters and coolers for specific applications.

21—Oil Burners

National Airoil Burner Company, 1284 East Sedgley Avenue, Philadelphia 34, has available Bulletin No. 21, on steam atomizing oil burners and auxiliary equipment for use with heavy oil or tar in boiler and still furnaces.

22—Refractories

The Carborundum Company, Niagara Falls, New York, is distributing a handsome brochure, "How Carborundum Serves Industry," which in addition to telling the story of the discovery and development of silicon carbide and development of its use as an abrasive, contains data on refractories made from this material.

23—Bore Inspection

Lenox Instrument Company, 2010 Chancellor Street, Philadelphia 3, has available a booklet on its line of tubescopes and borescopes, including new developments and uses devised during the war period.

24—Duplex Tubing

Bridgeport Brass Company, Bridgeport, Connecticut, has available a technical bulletin on applications and methods of installing duplex tubing. This tubing is available with steel, aluminum, Monel or stainless steel outside, with copper, brass or nickel inside.

25—Refrigeration Compressors

Worthington Pump and Machinery Corporation, Harrison, New Jersey, has issued Bulletin C-1100-B26, on its vertical, two-cylinder, single acting enclosed refrigeration compressors.

26—Hydraulic Decoking

Worthington Pump and Machinery Corporation, Harrison, New Jersey, has issued a new bulletin, WP-1099-B20C, on hydraulic decoking systems for the oil refining industry. In 12 pages of descriptive text and pictures it gives data on operation, costs and economies of handling coke.

27—Diesel Engines

Diesel Engine Manufacturers Association, One North LaSalle Street, Chicago 2, is distributing a 32-page booklet, "The Story of the Diesel," which is a non-technical discussion of the history and future of diesel power.

28—Electronics

North American Philips Company, 100 East 42nd Street, New York 17, recently has issued a condensed catalog, "Norelco Electronic Products." Included are descriptions of film-type X-ray diffraction equipment and the new Geiger-Counter X-ray spectrometer.

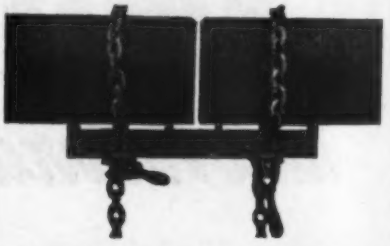
29—Steam Plant Equipment

Yarnall-Waring Company, Chestnut Hill, Philadelphia 18, has issued a folder which describes a 16-mm. sound motion picture film designed for showing before technical societies, trade groups, engineering schools, and engineers and operating men in industry. The bulletin tells how arrangements may be made for showing.

30—Heaters and Coolers

American District Steam Company, North Tonawanda, New York, has issued a new 12-page Bulletin No. 35-76B on ADSCO heaters and coolers, including three new types, with dimensions, capacity tables and list prices on units suitable for use as instantaneous heaters, condensate coolers, preheaters, fuel-oil heaters, etc.

Centrifugal Pump Engineer able to take charge of design of pumps for refinery use. Record of experience should be submitted. Address: Box 70, c/o Petroleum Refiner, Houston, Texas.



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